

SIMULATION OF QIBLA USING SPREADSHEET

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Abstract: The direction of the Qibla is one of the important elements in carrying out prayer for Muslims. Accuracy in determining the direction of the Qibla is a must so that worship can be carried out according to sharia. There is a need to provide a simple, inexpensive, and easily accessible alternative solution to determine the direction of the Qibla. One tool that can be utilized is spreadsheet software, such as Microsoft Excel or Google Sheets. Spreadsheets have become a versatile tool in various fields, including finance, education, and science. Spreadsheets can display mathematical representations in tables so that they can be better understood. This simulation consists of two simulations, namely the first displays a simulation of the direction of the Qibla in one location, and the second displays a simulation of the direction of the Qibla in the Indonesian region. The first simulation can display the direction of the Qibla anywhere on the surface of the earth. The direction of the Qibla is displayed in degrees and degrees, minutes, seconds. The second simulation displays a graph of the direction of the Qibla at various latitudes in the Indonesian region.

Keywords: Qibla, Simulation, Spreadsheet.

Introduction

The direction of the Qibla is one of the important elements in carrying out prayer for Muslims. Accuracy in determining the direction of the Qibla is a must so that worship can be carried out according to sharia. Traditionally, determining the direction of the Qibla is done using a compass or with the help of natural objects such as the shadow of the sun (Mutia Hanum & Ismail, 2022). However, along with the development of technology, modern methods such as GPS (Global Positioning System)-based applications have begun to be widely used. Although this technology offers a high level of accuracy, not everyone has easy access to these devices or applications. Cost factors, limited internet networks, or lack of technical understanding are often obstacles (Rakhmadi & Setiawan, 2020). In this context, there is a need to provide a simple, inexpensive, and easily accessible alternative solution to determine the direction of the Qibla. One tool that can be utilized is spreadsheet software, such as Microsoft Excel or Google Sheets. Spreadsheets have become a versatile tool in various fields, including finance, education, and science (González, 2018). With the ability to perform mathematical calculations, data analysis, and simulations, spreadsheets have the potential to be used to accurately determine the direction of the Qibla. In addition, its universal and easy-to-understand nature makes it accessible to various levels of society (Katoch, 2020).

The use of spreadsheets for simulating the direction of the Qibla is based on the principles of astronomical and geodetic calculations. In determining the direction of the Qibla, the main parameters needed are the geographic coordinates of the user's location (latitude and longitude) and the coordinates of the Kaaba in Mecca. By using a mathematical formula to calculate the azimuth of the Qibla, spreadsheets can provide accurate results. This Qibla azimuth formula involves spherical trigonometry, which although complex, can be automated in spreadsheets so that users only need to enter their location data (Wahyuni et al., 2023).

In addition to accuracy, another advantage of this simulation is its flexibility. Spreadsheets can be designed with a simple interface, making them easy to use by users without a technical background. Users simply enter their location coordinates, and the spreadsheet will automatically calculate the direction of the Qibla and present it in a visual form, such as an arrow or graph. This can also improve users' understanding of the concept of calculating the direction of the Qibla, making it not only a practical tool but also an educational medium.

In the field of education, the simulation of the direction of the Qibla using spreadsheets has great potential to be used as teaching materials. For example, in Islamic schools or madrasas, students can be taught how the principles of mathematics and geography are applied in everyday life. This approach not only enriches their knowledge but also builds useful practical skills (Raisal et al., 2022). However, like other technologies, the simulation of the direction of the Qibla using spreadsheets also has limitations. One of them is the dependence on computer devices or smartphones that support spreadsheet applications. In addition, although spreadsheets are designed to make it easier for users, a basic understanding of data input and interpretation of results is still required (Katoch, 2020). Therefore, clear and easy-to-understand guidelines are needed so that this simulation can be used effectively by the wider community.

Considering these advantages and disadvantages, the simulation of the direction of the Qibla using spreadsheets offers an innovative solution that is relevant to the needs of modern society. This article aims to outline the implementation method of such simulations, including calculation steps, interface design, and potential for future development. It is hoped that this approach will not only help Muslims in determining the direction of the Qibla independently and accurately, but also encourage the use of simple technology for the common good.

Literature Review

Qibla is something that is very important for Muslims. This is because the Qibla is one of the requirements for performing prayers. If the prayer that is performed does not face the Qibla, then the prayer is categorized as invalid or invalid. Qibla is the direction in which every Muslim faces when performing worship, especially prayer (Jaya, 2018). Qibla can also mean the Kaaba, because Muslims face it when praying (Rakhmadi & Setiawan, 2020). The Kaaba is a building that approaches the shape of a cube located in the center of the city of Mecca (Mutia Hanum & Ismail, 2022). The direction of the Qibla can be determined by the mathematical equation of spherical trigonometry. Calculating the Qibla with spherical trigonometry requires three points on the Earth's globe, namely the point at the North Pole, at the Kaaba, and in the area where the direction of the Qibla is to be found (Jaya, 2018).

Simulation is a type of visualization that can make it easier to investigate cause-and-effect relationships. Simulation is generally defined as an imitation of the operation of a real-world process or system over time. In interactive simulations, users are usually allowed to change some parameters of the simulated system and visualize the consequences of these changes (Dervić et al., 2018). The use of simulations can improve a person's understanding of what they are learning (Apriandi & Setyansah, 2017). Simulations basically make it easier for individuals to understand how a system works. This simulation contains learning efforts and can function as a learning medium that can improve understanding quickly because it is supported by interesting features so that students can later become active learners (Sujana & Supeno, 2020). Simulations can be expected to be an effective tool in helping students explore higher levels of learning abilities such as analysis, synthesis, and evaluation (Eso, 2018). Good simulations can be effective in improving rapid understanding of difficult topics (Ndihokubwayo et al., 2020).

The simulation in this study used spreadsheet software. The reason is because students are already familiar with spreadsheets and spreadsheets do not require complicated programming (Rani et al., 2022; Uddin et al., 2017). Users do not need to learn a programming language to use it (Weber & Wilhelm, 2020). Spreadsheets are very useful computational and graphical tools for creating simulations and visualizations (Clarke & Giraldo, 2009; Pratidhina et al., 2020). Spreadsheets also provide easy and simple calculation tools (Sokolova et al., 2018). Currently, spreadsheets provide tools that allow the development of automated procedures such as to obtain animation effects using very simple programming commands (Oliveira & Nápoles, 2010). Through spreadsheet programs, the resulting curves are smoother, more dynamic, and can be modified according to the given values (Putranta & Kuswanto, 2018). The usefulness of spreadsheets as a learning/teaching tool lies in their simplicity and user friendliness, built-in graphical capabilities, flexibility in changing model parameters, universal availability, and the ability to be used as or in combination with a word processor (Lwin, 2000). The use of graphs in spreadsheets can make learning interactive (Grigore et al., 2016).

Method

The direction of the Qibla on the Earth's surface can be calculated using the mathematical equation of spherical trigonometry. Calculating the Qibla using spherical trigonometry requires three points on the globe, namely the point at the North Pole, at the Kaaba, and in the area where the direction of the Qibla is to be found (Jaya, 2018). The equation used to calculate the direction of the Qibla is as follows.

$$X = \arctan \left(\frac{\sin(\lambda_x - \lambda_k)}{\tan \phi_k \cos \phi_x - \sin \phi_x \cos(\lambda_x - \lambda_k)} \right) \tag{1}$$

Where X is the Qibla angle, the Qibla angle of the city to be found, is the longitude of the location, is the longitude of the Kaaba, is the latitude of the Kaaba, and is the latitude of the location (Wahyuni et al., 2023). If we use a compass to determine the direction of the Qibla, we need the Qibla azimuth. The Qibla azimuth is the angle calculated from the north point clockwise through the horizon to the projection of the Kaaba. Azimuths of 90°, 180°, and 270° indicate the directions east, south, and west, respectively. The value of X here depends on the denominator and numerator of the right side of the tan X formula. For simplicity, tan X can be written as $\frac{y}{x}$. Therefore, the appropriate angle value of X also depends on the positive or negative values of x and y. In Ms. Excel, X can be determined with the format atan2(x;y) (Anugraha, 2012).

- a. If x is positive and y is positive, tan(X) is positive which results in 0 < X < 90.
- b. If x is negative and y is positive, tan(X) is negative which results in 90 < X < 180.
- c. If x is negative and y is negative, tan(X) is positive which results in 180 < X < 270 or – 180 < X < –90.
- d. If x is positive and y is negative, tan(X) is negative which results in 270 < X < 360 or – 90 < X < 0. For the last two cases above, if X is negative, add 360 degrees.

The spreadsheet simulation consists of a main spreadsheet and a secondary spreadsheet that interacts with the main spreadsheet. The main spreadsheet consists of two simulations, the first showing a simulation of the direction of the Qibla in one location, and the second showing

a simulation of the direction of the Qibla in the Indonesian region. In the secondary spreadsheet, intermediate calculations are performed for the results of the main sheet.

Result and Discussion

The first main spreadsheet display consists of input data and the results of the Qibla direction. The parameters that can be input and changed are the geographical coordinates of the place where the Qibla direction will be searched. The Scroll Bar and Option Button are used to change the input data. This is done to make the simulation more interesting. Figure 1 shows the display of determining the Qibla direction at a place. The yellow cell is where the latitude and longitude data of the location are entered. The latitude and longitude data entered are divided into degrees, minutes, and seconds. The Scroll Bar is used to change the values in the cell. The Option Button changes the type of latitude and longitude data. The orange cell shows the Qibla direction from the desired location. The Qibla direction obtained is displayed in two types, namely displayed in the form of degrees and degrees, minutes, seconds.

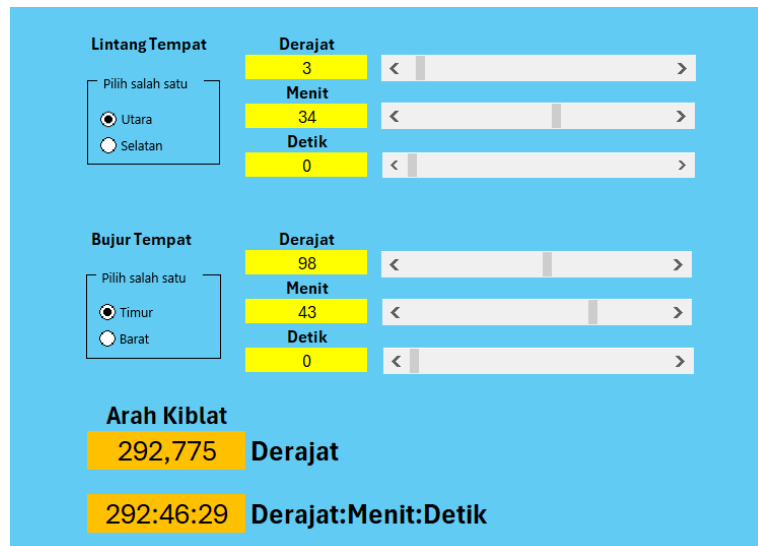


Figure 1. The first main spreadsheet display

Figure 2 shows the secondary spreadsheet for the calculations used in the first main spreadsheet display. The location coordinate data entered in the main spreadsheet is then calculated in the secondary spreadsheet. The location data and coordinates of the Kaaba are calculated using equation 1 to obtain the Qibla direction value.

| | A | B | C | D | E | F | G | H | I |
|----|---|------------------------|----------------|----------------|---|--------------------------------------------------------------------------------------------------------------------|---|---|---|
| 1 | | | Derajat | Derajat | | | | | |
| 2 | | Lintang Tempat | 3,566666667 | 3,56667 | | | | | |
| 3 | | | | | | | | | |
| 4 | | Bujur Tempat | 98,71666667 | 98,7167 | | | | | |
| 5 | | | | | | | | | |
| 6 | | Lintang Kabah | 21,423 | | | $X = \arctan \left(\frac{\sin \Delta \lambda}{\tan \phi_x \cos \phi_y - \sin \phi_x \cos \Delta \lambda} \right)$ | | | |
| 7 | | | | | | | | | |
| 8 | | Bujur Kabah | 39,828 | | | | | | |
| 9 | | | | | | | | | |
| 10 | | | | | | | | | |
| 11 | | y | -0,85617 | | | | | | |
| 12 | | x | 0,359455353 | | | | | | |
| 13 | | tan arah kiblat | -2,381851868 | | | | | | |
| 14 | | Sudut Azimut AK | -67,22531968 | | | | | | |
| 15 | | Sudut Azimut AK | 292,7746803 | | | | | | |
| 16 | | Sudut Azimut AK | 292:46:29 | | | | | | |
| 17 | | | | | | | | | |
| 18 | | | | | | | | | |
| 19 | | | | | | | | | |

Figure 2. Secondary spreadsheet for calculations on the first main spreadsheet display

The second main spreadsheet display consists of input data and a graph of the direction of the Qibla in the Indonesian region. The parameters that can be input and changed are the latitude of the place that is within the range of the Indonesian region. Indonesia is in the latitude range of -6 degrees - 11 degrees or 6 degrees south latitude to 11 degrees north latitude. The yellow cells indicate the latitude of the place used. The Scroll Bar is used to change the latitude data of the place. The range of values on the Scroll Bar is -6 - 11 according to the latitude of the Indonesian region. The graph displays the direction of the Qibla in the Indonesian region at the specified latitude. The x-axis shows the longitude of the place, and the y-axis shows the azimuth of the Qibla.

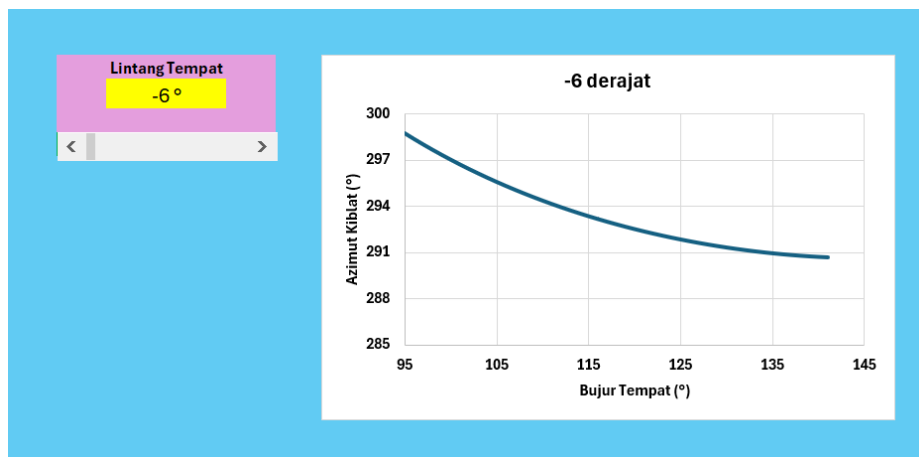


Figure 3. The second main spreadsheet display

Figure 4 shows a graph of the direction of the Qibla in the Indonesian region located at latitudes of -6 degrees, 0 degrees, 4 degrees, and 11 degrees. The Indonesian region located at latitude -6 degrees has a Qibla direction value in the range of 291 - 299 degrees. The Indonesian region located at latitude 0 degrees has a Qibla direction value in the range of 291 - 296 degrees. The Indonesian region located at latitude 4 degrees has a Qibla direction value in the range of 291 - 293 degrees. The Indonesian region located at latitude 11 degrees has a Qibla direction value in the range of 288 - 293 degrees. One method of determining the Qibla direction that is

often used by the Indonesian people is to make the west direction as the Qibla direction (Muthmainnah et al., 2019). The west direction has an azimuth value of 270 degrees. From Figure 4, it can be seen that none of the Qibla azimuth values obtained have a value of 270 degrees. This indicates that the west direction cannot be used as a reference as the Qibla direction in Indonesia.

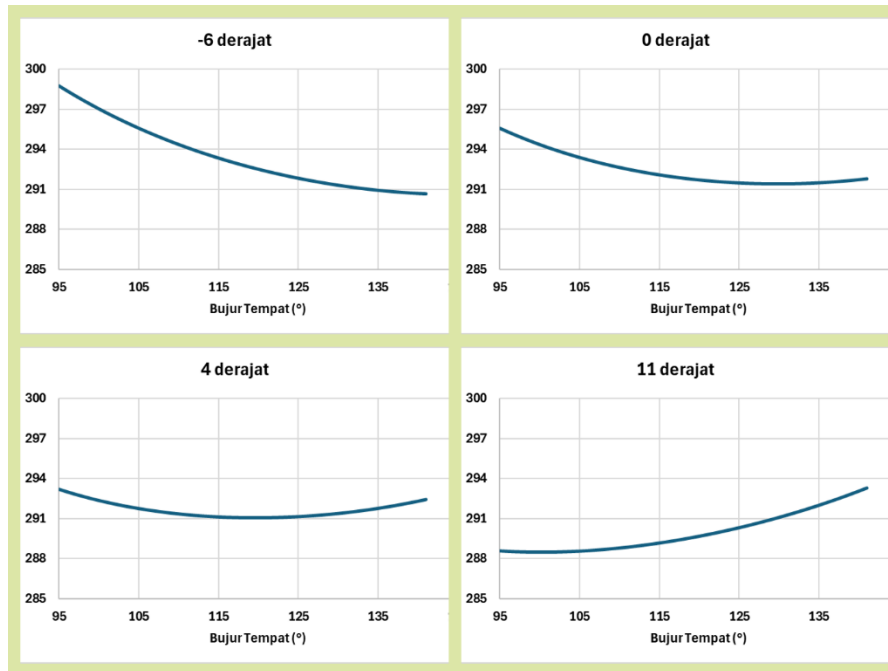


Figure 4. Qibla direction graph in the Indonesian region at latitudes -6, 0, 4, and 11 degrees.

Figure 5 shows a secondary spreadsheet for the calculations used in the second main spreadsheet display. The parameter that is changed in the second main spreadsheet is the latitude of the place. Meanwhile, the longitude of the place in the calculation is not changed. The territory of Indonesia is in the range of 95 - 141 degrees east longitude. The table in this secondary spreadsheet is used to create graphs.

| | A | B | C | D | E | F | G | H | I | J | K | L |
|----|---------------|------------------|--------------|----------------|------------|----------------------|----------------------|---|---|---|---|---|
| 1 | Lintang Kabah | 21,423 | | Lintang tempat | 11 | | 11 derajat | | | | | |
| 2 | Bujur Kabah | 39,828 | | | | | | | | | | |
| 3 | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | |
| 5 | | Bujur (°) | y | x | y/x | Azimut AK (°) | Azimut AK (°) | | | | | |
| 6 | | 95 | -0,820875192 | 0,276177655 | -2,97227 | -71,4048509 | 288,5951491 | | | | | |
| 7 | | 96 | -0,830717371 | 0,278927829 | -2,97825 | -71,4396263 | 288,5603737 | | | | | |
| 8 | | 97 | -0,840306505 | 0,28171036 | -2,98287 | -71,46641973 | 288,5335803 | | | | | |
| 9 | | 98 | -0,849639674 | 0,284524399 | -2,98618 | -71,48551049 | 288,5144895 | | | | | |
| 10 | | 99 | -0,858714035 | 0,287369089 | -2,98819 | -71,49715627 | 288,5028437 | | | | | |
| 11 | | 100 | -0,867526823 | 0,290243565 | -2,98896 | -71,50159476 | 288,4984052 | | | | | |
| 12 | | 101 | -0,876075354 | 0,29314695 | -2,98852 | -71,49904501 | 288,500955 | | | | | |
| 13 | | 102 | -0,884357024 | 0,29607836 | -2,9869 | -71,48970872 | 288,5102913 | | | | | |
| 14 | | 103 | -0,89236931 | 0,299036902 | -2,98414 | -71,4737714 | 288,5262286 | | | | | |
| 15 | | 104 | -0,900109772 | 0,302021676 | -2,98028 | -71,45140339 | 288,5485966 | | | | | |
| 16 | | 105 | -0,907576051 | 0,305031771 | -2,97535 | -71,42276083 | 288,5772392 | | | | | |
| 17 | | 106 | -0,914765875 | 0,30806627 | -2,96938 | -71,38798653 | 288,6120135 | | | | | |
| 18 | | 107 | -0,921677051 | 0,311124251 | -2,96241 | -71,34721074 | 288,6527893 | | | | | |
| 19 | | 108 | -0,928307476 | 0,31420478 | -2,95447 | -71,30055185 | 288,6994482 | | | | | |
| 20 | | 109 | -0,93465513 | 0,31730692 | -2,94559 | -71,24811708 | 288,7518829 | | | | | |
| 21 | | 110 | -0,940718078 | 0,320429725 | -2,9358 | -71,19000304 | 288,809997 | | | | | |
| 22 | | 111 | -0,946494475 | 0,323572245 | -2,92514 | -71,12629626 | 288,8737037 | | | | | |

$$X = \arctan\left(\frac{\sin \Delta\lambda}{\tan \phi_K \cos \phi_X - \sin \phi_X \cos \Delta\lambda}\right)$$

Figure 5. Secondary spreadsheet for calculations on the second main spreadsheet display

Conclusion

In this article we show one of the uses of spreadsheets in astronomy, namely the simulation of the direction of the Qibla. Spreadsheets can display mathematical representations in tables so that they can be better understood. This simulation consists of two simulations, namely the first displays a simulation of the direction of the Qibla in one location, and the second displays a simulation of the direction of the Qibla in the Indonesian region. The first simulation can display the direction of the Qibla anywhere on the surface of the earth. The direction of the Qibla is displayed in degrees and degrees, minutes, seconds. The second simulation displays a graph of the direction of the Qibla at various latitudes in the Indonesian region.

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