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# COMPARING CHOROPLETH AND GRADUATED SYMBOLS: HOW DIFFERENT MAP TYPES AFFECT PUBLIC UNDERSTANDING IN COVID-19 MAP READING IN BADUNG REGENCY, BALI, INDONESIA

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**ABSTRACT:**
Information on COVID-19 is vital in protecting the entire community. As the diffusion pattern changes rapidly over time, originally simple data must be presented differently to provide more representative and quickly readable information. Relevant data are now offered in maps to support the public dissemination of COVID-19 information, with Choropleth and Graduated Symbols being the most common map types. This research was the first to analyze community's map reading skills, particularly in interpreting or understanding Indonesia's COVID-19 case distribution portrayed on the map. To test both map types, an online questionnaire was sent to respondents selected by random sampling from people living in Badung Regency. Then, they were given 11 tasks, namely to identify, find extreme values, differentiate, retrieve values, compare, interpret, categorize, group, sort, associate, and locate information contents on both maps. Then, chi-squared, Cramer's V, and Mann-Whitney U tests were conducted to statistically analyze three aspects: accuracy, time, and level of difficulty. The results showed that the choropleth map was easier to read than the graduated symbols. Furthermore, the null hypothesis (H0) was rejected, which means there is a correlation between map type and community's ability to read and understand maps.

***Key-words:*** *COVID-19, Map Reading, Map Type, Statistics.*

## 1. INTRODUCTION

In 2020, the world was hit by the novel coronavirus disease COVID-19. It was first discovered in December 2019 in Wuhan, the capital of China's Hubei Province, and has since spread throughout the world (Wu, Chen & Chan, 2020; Zhou et al., 2020). The World Health Organization (WHO) declared the 2019–2020 outbreak a Public Health Emergency of International Concern (PHEIC) on January 30, 2020, and a pandemic on March 11, 2020 (El Hakim, Tourab & Zouiten, 2020; Leite et al., 2021).

In the last two years, the COVID-19 pandemic has shaken the global population tremendously. With almost every country in the world reporting infection cases (Cascella et al., 2020), governments have mainly focused on introducing various efforts to curb the spread and inform the community about how and to what extent the disease diffused. This effort includes presenting useful, relevant data to facilitate case updates and instill public understanding. Currently, COVID-19 distributions are mostly described in the form of statistical data, which can be correctly understood when visualized appropriately and according to the purpose of the data usage.

Thematic maps are a commonly used visualization method to convey statistical data (Sudaryatno, El-Yasha & Afifah, 2019, Korycka-Skorupa & Gołebiowska, 2020).

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Geographic Information System (GIS) and cartography are two different fields of study that share the map concept. GIS refers to a set of technologies that include the interface of hardware, software, data, procedures, and networks. GIS is used to store, display and represent, interpret, and analyze geospatial data. In other words, GIS is a group of information systems that store and represent data that are associated with specific places in the real world. (Cantwell & Milem, 2010; Prah & Štrubelj, 2018). GIS can show many different kinds of data in one map, such as streets, buildings, and vegetation. This enables people to see, analyze, and understand patterns and relationships more easily. During recent years, maps have become very popular and frequently produced cartographical outputs. Cartography deals with the method expression and communication of these facts and phenomena with symbols and graphs on a map (Voženílek, & Bělka, 2016; Kraak & Fabrikant, 2017).

Nowadays, most GIS software incorporates advanced representation and labeling possibilities, and thanks to the database, there are multiple symbolization possibilities. Database is a collection of related information that permits the entry, storage, input, output, and organization of data. A database management system (DBMS) serves as an interface between users and their databases (Magyari-Sáska, 2020). Spatial database systems are concerned with the representation and manipulation of data that have a geometrical or topological interpretation of the physical world (Fekihal, Jaluta & Osman, 2012; Susanto & Meiryani, 2019). Spatial databases connect users to the GIS database. Then the database was visualized into a map.

Data visualization with thematic maps has its advantage, i.e., the map displays data by adding geographical symbols to represent statistical values while showing their location and spatial distribution (He, Tang & Huang, 2011; Pánek, 2020). However, its effectiveness statistically depends on how frequently the target populations read maps. Also, it should be noted that GIS data representation needs to be adjusted to the circumstances of the map users (Havelková & Hanus, 2019; Słomska-Przech, Panecki & Pokojski, 2021).

The application of GIS is applied in various fields of study, one of which is in the health sector. There have been studies regarding the application of geospatial analysis in COVID-19, especially the studies that were focused on understanding the distribution patterns of the pandemic. The widespread use of GIS for COVID-19 response has demonstrated the power of geospatial technology in a spatial, territorial, locational and landscape perspective. The online dashboard, maps and near-live tracking of cases and COVID-19 related fatalities were the first of its kind and aided the scientific community and practitioners in comprehending the magnitude of the pandemic, distribution of vulnerability until the smallest neighborhood and act as a critical source of information during this pandemic (Dong, Du, & Gardner, L., 2020, Franco-Pardo, 2020, Ahasan, & Hossain, 2021, Permatasari, et al., 2021, Ahasan, et al.,2022).

As one of the countries severely hit by the pandemic, Indonesia draws on the ability and advantage of thematic maps to help produce chiefly choropleth and graduated symbol maps to visualize infection cases at the provincial and regency levels. **Fig. 1** shows the graduated symbol and choropleth maps of COVID-19 distribution in Indonesia derived from covid19.go.id (COVID-19 Handling Task Force, 2021a; COVID-19 Handling Task Force, 2021b).

The graduated symbol map contains red circles proportional to provincial cases—with nationwide cases as the comparison, while the choropleth map divides the provinces into four risk categories: high (colored red), moderate (orange), low (yellow), and no cases (green). Both show that Bali is among the provinces at risk and with a relatively high number of reported cases. Therefore, to contain the spread and prevent new COVID-19 outbreaks, it is imperative that the right map be disseminated to visualize and educate the public about the spatial distribution of COVID-19 and identify the highly impacted areas in Bali.

In the province, a high cumulative COVID-19 case can be found in Badung Regency. Most of its area is tourist destinations; therefore, to observe and anticipate potential COVID-19 spread, the regency requires comprehensive information to be presented in an easy-to-understand map. This study aimed to analyze the public understanding of the COVID-19 distribution data in Badung Regency using two subtypes of thematic maps, namely graduated symbol map and choropleth map.

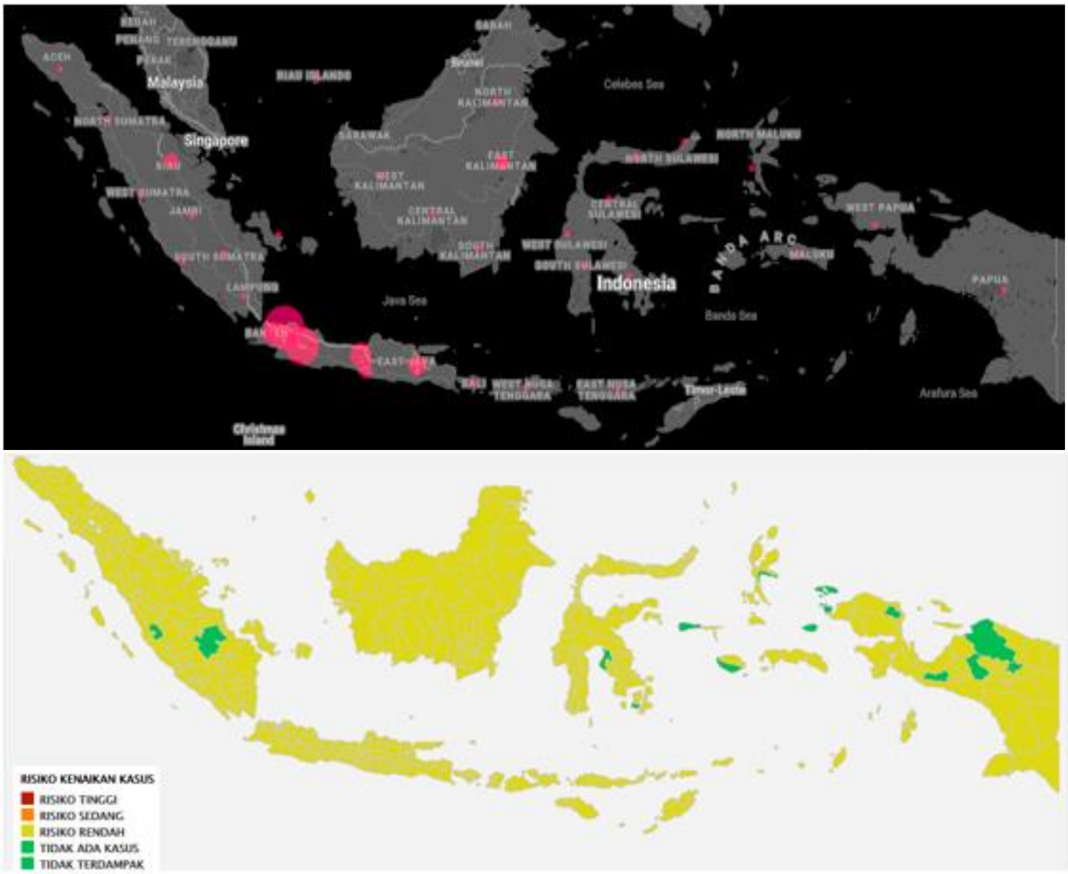


**Fig. 1.** The graduate symbol (top) and choropleth map (bottom) visualizing COVID-19 case distribution in Indonesia.

## 2. STUDY AREA

The study area is Badung Regency, Bali Province, Indonesia, which lies from 8°14’20” to 8°50’52” S and from 115°55’03” to 115°26’51” E. Badung has an area of 418.52 km$^2$ consisting of six districts: Kuta Selatan, Kuta, Kuta Utara, Mengwi, Petang, and Abiansemal, and 62 villages (Krisnandika, Wijaya & Ambarawati et al., 2019, BPS-Statistics of Badung Regency, 2019). **Fig. 2** shows the research location.

## 3. DATA AND METHODS

This study used COVID-19 distribution data in 62 villages of the six districts in the Badung Regency. It aimed to analyze the community's ability to read or understand statistical data presented in thematic maps, i.e., graduated symbol and choropleth maps. The map reading test refers to the use of comparison matrices and different tasks—expressed in questions or commands—formulated and tested by Słomska-Przech and Galebiowska (2021). Participants were asked to compare which map was easier to understand by firstly completing eleven tasks: to identify, to find extreme values, to distinguish, to retrieve values, to compare, to interpret, to categorize, to group, to sort, to associate, and to locate. Then, the responses to these tasks were analyzed from three aspects: accuracy, time, and difficulty level. Accuracy measures how accurately the public answers each question or responds to each command. Time measures the speed with which the public responds, while the level of difficulty indicates how the public assesses the difficulty of the tasks given for each map. **Fig. 3** shows the maps sent to participants for the map reading test.

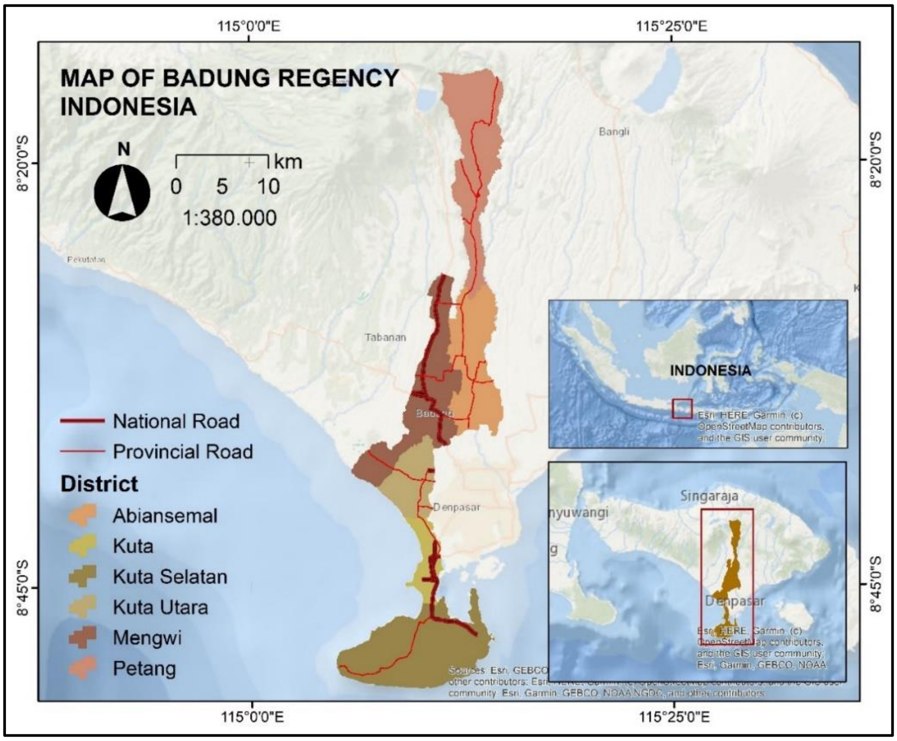


**Fig. 2.** Research location.

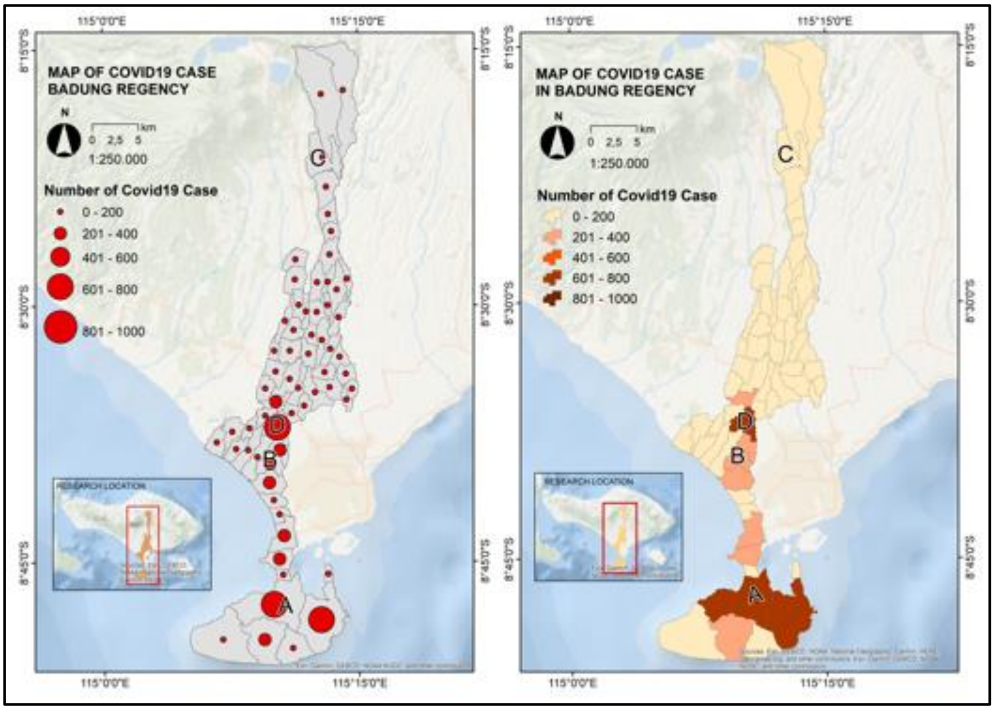


**Fig. 3.** COVID-19 case distribution maps for the map reading test: graduated symbols map (left) and choropleth map (right).

The test involved 120 participants or respondents selected by random sampling from the people living in Badung Regency. They were divided into two groups: 60 were asked to read the choropleth map and 60 others read the graduated symbols map. The respondents were 18−35 years old, comprising 77.5% female (93 respondents) and 22.5% male (27). Regarding their map reading frequency, 24.2% (29) stated that they never used or read maps, 23.3% (28) read maps once a week, and the remainder 52.5% (63) read or used maps more than once a week, be it Google Maps, Google Earth, or other applications with map features. The age range was selected based on the assumption that the respondents in this demography were more active in searching for information related to COVID-19 and more accustomed to using information and communication technology, including maps.

The research was the first to analyze the best map for understanding COVID-19 pandemic distribution in Indonesia. It employed an experimental research design that tested three aspects of map reading using descriptive statistical analysis: accuracy, time, and difficulty level. In addition, it also analyzed the correlation between two variables, namely map type and the public's ability to read maps using Chi-squared, Cramer's V, and Mann-Whitney U tests, which were selected for analysis because of the nature of data (Ahammed & Smith, 2019). In light of this, the formulated hypothesis was as follows:

*Ho: There is no correlation between map type and the public's ability to understand the map*
*H1: There is a correlation between map type and the public's ability to understand the map*

Pearson's chi-square test was used to test the significance of a categorical variable relationship. However, it cannot measure how closely related or correlated the two categorical variables are. To measure the closeness of the relationship between categorical variables, which can use the Phi coefficient, the coefficient of congruence and the Cramer's V correlation. According to Field (2009) and Okeke (2019) the three tests can both describe the relationship between two variables if the data matrix is 2x2. However, when the variable has more than two categories or different matrix dimensions, Cramer'V produces the best value. Therefore, in the case of this study, the Cramer'v correlation test is used because the matrix formed in this case is 2x2 for accuracy and 2x3 for difficult.

The use of the chi square test table is also equipped with the results of the Fisher's exact test which can also test the significance of the relationship between two variables. The condition for using the Pearson chi-square test is that when there are cells or squares, with an expected frequency value of less than 5, then the Pearson chi-square statistical sampling distribution will get inaccurate results. The analysis in this study resulted in 0% expected frequency value of less than 5 so, the chi square test was appropriate to be used in this analysis (McHugh, 2013; Kim, 2017).

While the Mann Whitney U Test is a non-parametric test used to determine the difference in the median of 2 independent groups if the dependent variable data scale is ordinal or interval/ratio but not normally distributed. Based on this definition, the Mann Whitney U Test requires data to be on an ordinal, interval or ratio scale (Hazra & Gogtay, 2016; Siddiqui, et al., 2016). In the cases tested, for testing accuracy and difficult, the Chi-Square method is used because the data used is on an ordinal category. Meanwhile, Time uses two types of data, namely ordinal and ratio. That is ordinal for map type and ratio for time. Time data were gathered from 2 groups, in which the variables are independent of each other, meaning that the data comes from different groups or are not paired so that the Man Whitney U Test method is used.

The test instrument sent online to the respondents contained eleven (11) tasks with corresponding questions or commands. The respondents were asked to pinpoint the label A, B, C, or D or their combinations on the map (T2, T3, T7, T8), to choose a sentence that correctly described the marked area on the map (T1, T5, T6, T10, T11), to sort the data according to the instructions (T9), and to determine the amount of data (T4). Questions were inputted and set in a census-based mobile phone application; hence, the online data collection process. The tasks and their respective questions or commands are presented in **Table 1**. **Fig. 4** shows the research flowchart.

**Table 1.**
**Tasks, questions or commands, and answer options for the Map Reading test.**

| Code | Task | Question/Command | Answer Options |
|---|---|---|---|
| **T1** | **To identify** | Choose the sentence that correctly describes the area with 201 to 400 COVID-19 patients. | A. In the northern part of the research area |
| | | | B. In the southern part of the research area |
| | | | C. At the center of the research area |
| | | | D. In the northern and southern parts of the research area |
| **T2** | **To find extreme values** | Choose a location with the highest reach of COVID-19 cases. | A. A-B |
| | | | B. A-C |
| | | | C. A-D |
| | | | D. B-D |
| **T3** | **To distinguish** | Choose an area whose COVID-19 patients are in the range of 201–400 and 601–800. | A. A-B |
| | | | B. A-C |
| | | | C. A-D |
| | | | D. B-A |
| **T4** | **To retrieve values** | What is the range of the number of COVID-19 patients in region D? | A. 201–400 |
| | | | B. 401–600 |
| | | | C. 601–800 |
| | | | D. 801–1000 |
| **T5** | **To compare** | Identify the area(s) showing the lowest and highest reach of COVID-19 cases. | A. Located at the south and center of the map |
| | | | B. Located at the edge of the map |
| | | | C. Located at the north, south, and center of the map |
| | | | D. Located at the north and edge of the map |
| **T6** | **To interpret** | Choose the right sentence. | A. Region B has the highest number of COVID-19 cases |
| | | | B. Regions B and D have the same range of COVID-19 cases |
| | | | C. All areas bordering Region C have the same range of COVID-19 cases |
| | | | D. Region A has the same range of COVID-19 cases as the neighboring area on the west |
| **T7** | **To categorize** | Which region is marked with the lowest COVID-19 case? | A. D |
| | | | B. C |
| | | | C. B |
| | | | D. A |
| **T8** | **To group** | Group the regions that have the same range of COVID-19 cases. | A. A-B |
| | | | B. A-C |
| | | | C. A-D |
| | | | D. B-D |
| **T9** | **To sort** | Sort the regions in order of the lowest to highest COVID-19 cases. | A. A-B-C |
| | | | B. C-B-A |
| | | | C. D-C-B |
| | | | D. B-C-D |
| **T10** | **To associate** | Choose a sentence that describes the correlation between two areas. | A. Regions A and B have the same range of COVID-19 cases |
| | | | B. Regions A and B are located on the south side of the map |
| | | | C. Regions B and C have the same range of COVID-19 cases |
| | | | D. Regions A and D have the same range of COVID-19 cases |
| **T11** | **To locate** | Choose the sentence that describes the location with the highest number of COVID-19 cases. | A. Located at the south of the area |
| | | | B. Located at the edge of the area |
| | | | C. Located at the center and south of the area |
| | | | D. Located at the north of the area |

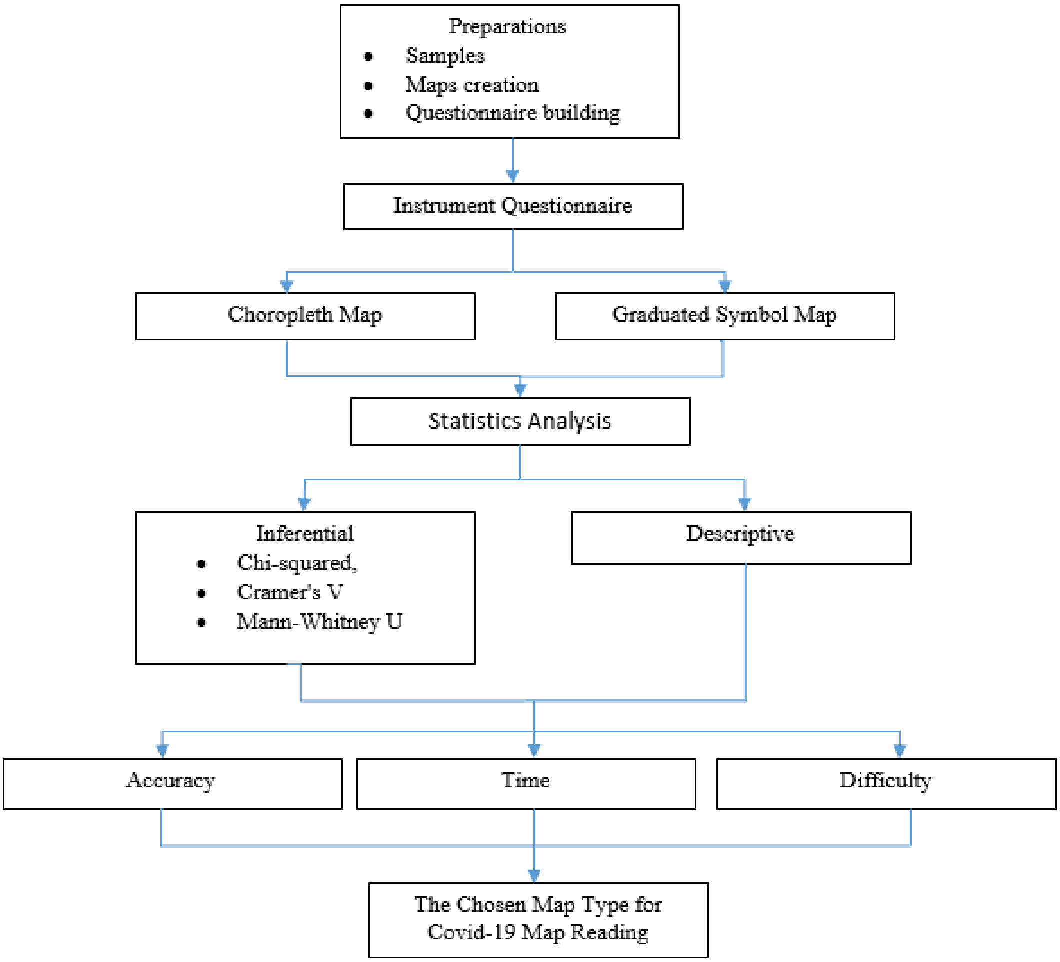


**Fig. 4.** The research flowchart.

## 4. RESULTS

This section presents the descriptive analysis results for three map reading aspects (accuracy, time, and difficulty level) and the correlation analysis between map type and the public's ability to read maps. **Figures 4, 5, and 6** show the accuracy of answers for each task, the difficulty of understanding the two COVID-19 maps based on the given task, and the speed of map reading. The average accuracy of answers for the 11 tasks was 68%. The best results were shown by the group of respondents who read the choropleth map, with 73% correct answers. For comparison, 63% correct answers were obtained from the graduated symbols map group. Regarding difficulty level, 54% of the respondents stated that it was easy to read the choropleth map type, whereas 11% found it difficult. As for the graduated symbols map, it was easy to read according to 25% of the respondents but difficult for the other 12%. Based on this information, it can be inferred that the shares of respondents perceiving the two maps as difficult to read were only slightly different. In addition, the average time to read the maps and answer each question or command was 31.97 seconds. The choropleth map group took 28.15 seconds, while the graduated symbols map group required a longer time to complete the task, averagely 35.78 seconds. Lastly, inferential statistics were employed to analyze the correlation between map type and the community's map reading ability. The sections below describe the correlation analysis with every aspect of map reading.

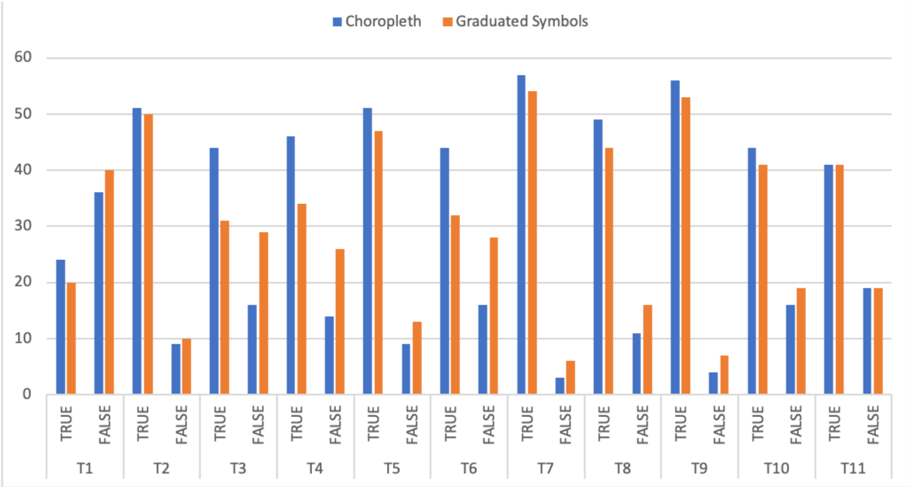


**Fig. 4.** Accuracy of answers in the COVID-19 map reading test for choropleth and graduated symbols maps per task (presented in frequency).

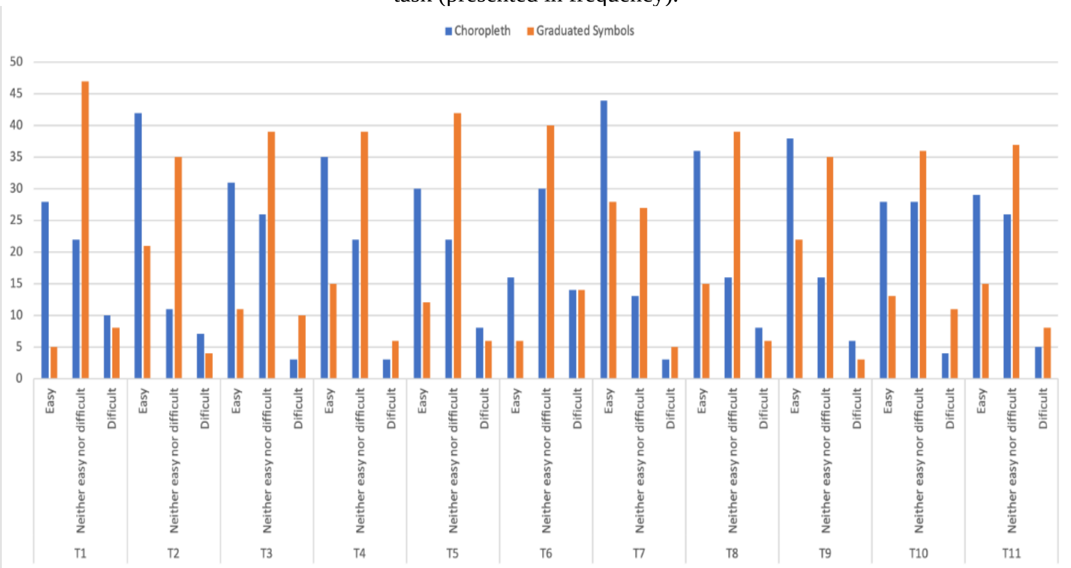


**Fig. 5.** Difficulty levels of the COVID-19 map reading for choropleth and graduated symbols maps per task (presented in frequency).

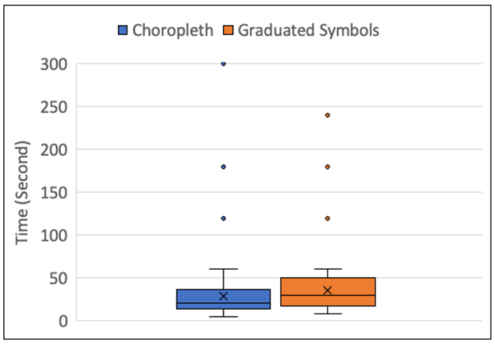


**Fig. 6.** Answer time boxplot for choropleth and graduated symbols maps.

The boxplot shows that the time data distribution on the graduated symbols map is more spread out than Choropleth, with the standard deviation obtained is 24.4 for GS and 22.1 for Choropleth. This proves that the data is not normally distributed so that the measurement of the center value is measured using the median with the Choropleth median is 30 seconds and Graduated Symbols is 21 seconds. **Table 2** shows the descriptive analysis for answer time.

**Table 2.**

**The descriptive analysis for Answer Time.**

| | Choropleth | Graduated Symbols |
|---|---|---|
| **count** | 660 | 660 |
| **mean** | 28,15 | 35,781818 |
| **std** | 22,142323 | 24,40256 |
| **min** | 5 | 8 |
| **25%** | 14 | 17,75 |
| **50%** | 21 | 30 |
| **75%** | 36 | 50 |
| **max** | 300 | 240 |

## 4.1. Correlation between Map Type and Accuracy of the Answer

The chi-squared and Cramer's V tests were used to determine the correlation between map type and the community's ability to read maps based on the first aspect, i.e., accuracy. In this case, the proposed hypothesis was as follows:

- *Ho: There is no correlation between map type and the accuracy of the answer as an aspect of the public's ability to understand the map*
- *H1: There is a correlation between map type and the accuracy of the answer as an aspect of the public's ability to understand the map*

**Tables 3 and 4** show the chi-square and Cramer's V test results, respectively. The first correlation analysis produced a Pearson chi-square of 13.808 and a significance value (p-value) of 0.0000. To test the null hypothesis, the chi-square value (count) was compared with the chi-square table, and it was found that the former was higher than the latter (13.808 > 3.841459), which means that H0 is rejected. Then, the p-value was deemed significant because it was smaller than 0.05 (p-value = 0.000 < 0.05), which means that H0 is rejected. Because the two analyses rejected the Ho, it can be concluded that there is a correlation between map type and the accuracy of the answer as an aspect or subset of the community's ability to understand the map. Furthermore, the Cramer's V test produced a value of 0.102 and a p-value of 0.0000 > 0.05. It means that there is a correlation between map type and the accuracy of the answer, confirming the chi-squared test results.

**Table 3.**

**Chi-Squared test results for the Answer Accuracy.**

| | Value | df | Asymptotic Significance (2-sided) | Exact Sig. (2-sided) | Exact Sg. (1-sided) |
|---|---|---|---|---|---|
| **Pearson Chi-Square** | 13.808[a] | 1 | .000 | | |
| **Continuity Correction** [b] | 13.373 | 1 | .000 | | |
| **Likelihood Ratio** | 13.846 | 1 | .000 | | |
| **Fisher's Exact Test** | | | | .000 | .000 |
| **Linear-by-Linear Association** | 13.797 | 1 | .000 | | |
| **N of Valid Cases** | 1.320 | | | | |

a. 0 cells (0.0%) have an expected count of less than 5. The minimum expected count is 211.50;

b. Computed only for a 2x2 table.

**Table 4.**
**Cramer's V test results for the Answer Accuracy.**

| | | Value | Approximate Significance |
|---|---|---|---|
| **Nominal by Nominal** | **Phi** | .102 | .000 |
| | **Cramer's V** | .102 | .000 |
| **N of Valid Cases** | | 1320 | |

**Table 5** shows the inferential statistical test results per task. It shows that only T3, T4, and T6 are significant. These results indicate a correlation between map type and accuracy for T3 To distinguish, T4 To retrieve values, and T6 To interpret. For T3, the chi-square count > chi-square table (6.009 > 3.841459), and the p-value was 0.014 < 0.05; both rejected the H0. In conclusion, there is a correlation between map type and the accuracy of the public in distinguishing a particular map object. For T4, the chi-square count > chi-square table (5.4 > 3.841459), and the p-value was 0.02 < 0.05; both rejected the H0. Thus, there is a correlation between map type and the accuracy of the public in retrieving values of a specific map object. Similarly, for T6, the chi-square count > chi-square table (5.167 > 3.841459), and the p-value was 0.023 < 0.05, rejecting the H0. These results indicate a correlation between map type and the accuracy of the public in interpreting a particular situation portrayed on the map.

**Table 5.**
**Inferential statistics for the Answer Accuracy.**

| Task | Chi-squared | *p* | Cramer's V | *p* |
|---|---|---|---|---|
| **T1 To identify** | 0.574 | 0.449 | 0.069 | 0.449 |
| **T2 To find extreme values** | 0.063 | 0.803 | 0.023 | 0.803 |
| **T3 To distinguish** | 6.009 | 0.014 | 0.224 | 0.014 |
| **T4 To retrieve values** | 5.4 | 0.02 | 0.212 | 0.02 |
| **T5 To compare** | 0.891 | 0.345 | 0.086 | 0.345 |
| **T6 To interpret** | 5.167 | 0.023 | 0.208 | 0.023 |
| **T7 To categorize** | 1.081 | 0.298 | 0.095 | 0.298 |
| **T8 To group** | 1.195 | 0.274 | 0.1 | 0.274 |
| **T9 To sort** | 0.901 | 0.343 | 0.087 | 0.343 |
| **T10 To associate** | 0.363 | 0.547 | 0.055 | 0.547 |
| **T11 To locate** | 0 | 1 | 0 | 1 |
| **ACCURACY** | 13.808 | 0.000 | 0.102 | 0.000 |

### 4.2. Correlation between Map Type and Answer Time

In addition to the accuracy of the answer, the correlation between map type and the public's ability to read maps was also tested using the second aspect, i.e., time. Therefore, the following hypothesis was formulated:

- *Ho: There is no correlation between map type and answer time as an aspect of the public's ability to understand the map*
- *H1: There is a correlation between map type and answer time as an aspect of the public's ability to understand the map*

**Table 6** shows the Mann-Whitney U test results for the answer time. The results included a significance value (p-value) of 0.000 < 0.05, thus rejecting the H0. In other words, there is a correlation between map type and the answer time as an aspect or subset of the community's map reading ability.

**Table 6.**
**Mann-Whitney U test results for the Answer Time.**

| Test Statistics | Time |
|---|---|
| **Mann-Whitney U** | 168566.500 |
| **Wilcoxon W** | 386696.500 |
| **Z** | -7.118 |
| **Asymo. Sig. (2-tailed)** | .000 |

**Table 7** shows the inferential statistical test results for the answer time per task. In general, the figures in this table indicate a correlation between map type and answer time. However, five tasks are insignificant because their p-values were higher than 0.05, i.e., T2 To find extreme values was 0.59, T3 To distinguish 0.945, T1 To identify 1,000, T9 To sort 0.069, and T10 To associate 0.18. These p-values indicate a failure to reject the null hypothesis (Ho). In other words, there is no correlation between map type and the time the public requires to understand maps, especially to find extreme values, to distinguish and categorize a particular object, to sort map objects based on a situation, and to associate or correlate two areas. In contrast, the Ho is rejected for T1, T4, T5, T6, T8, and T11, whose p-value was smaller than 0.05. Consequently, there is a correlation between map type and the time the public takes to understand the map, specifically to identify, retrieve values, compare, interpret, group, and locate objects on the map.

**Table 7.**
**Inferential statistics for the Answer Time.**

| Task | Mann-Whitney U | *p* |
|---|---|---|
| **T1 To identify** | 1073.5 | 0.000 |
| **T2 To find extreme values** | 1440 | 0.59 |
| **T3 To distinguish** | 1787 | 0.945 |
| **T4 To retrieve values** | 1050.5 | 0.000 |
| **T5 To compare** | 1388 | 0.03 |
| **T6 To interpret** | 1283 | 0.006 |
| **T7 To categorize** | 1800 | 1.000 |
| **T8 To group** | 935.5 | 0.000 |
| **T9 To sort** | 1454.5 | 0.069 |
| **T10 To associate** | 1348.5 | 0.18 |
| **T11 To locate** | 1004.5 | 0.000 |
| **TIME** | 168566 | 0.000 |

### 4.3. Correlation between Map Type and Difficulty of the Map-Reading Tasks

The third aspect tested to determine the correlation between map type and the public's ability to read maps is difficulty level. Similar to accuracy and answer time, this correlation was assessed using inferential statistics (the chi-squared and Cramer's V) to test the hypothesis below:

- *Ho: There is no correlation between map type and difficulty of the task as an aspect of the public's ability to understand the map*
- *H1: There is a correlation between map type and difficulty of the task as an aspect of the public's ability to understand the map*

**Tables 8 and 9** show the chi-squared and Cramer’s V test results for the difficulty level, respectively. To test the null hypothesis, the calculated chi-square value (count) was compared with the chi-square table, and the level of significance was set at 0.05. The results can be described as follows:

- *Chi-square count (125.282) > chi-square table (5.9915), then H0 is rejected*
- *P-value = 0.000 < 0.05, then H0 is rejected.*

The two analyses rejected the null hypothesis (Ho). In other words, there is a correlation between map type and the difficulty level of the map-reading task as an aspect or subset of the public's ability to understand the map. Furthermore, the Cramer's V test yielded a value of 0.308 and a p-value of 0.000 < 0.05. It can be concluded that there is a correlation between map type and the difficulty level of the map-reading tasks, confirming the chi-squared test results.

**Table 8.**

**Chi-Squared test results for the Task Difficulty.**

| | Value | df | Asymptotic Significance (2-sided) |
|---|---|---|---|
| **Pearson Chi-Square** | 125.282[a] | 2 | .000 |
| **Likelihood Ratio** | 127.788 | 2 | .000 |
| **Linear-by-Linear Association** | 73.031 | 1 | .000 |
| **N of Valid Cases** | 1.320 | | |

a. 0 cells (0.0%) have an expected count of less than 5. The minimum expected count is 76

**Table 9.**

**Cramer’s V test results for the Task Difficulty.**

| | | Value | Approximate Significance |
|---|---|---|---|
| **Nominal by Nominal** | **Phi** | .308 | .000 |
| | **Cramer's V** | .308 | .000 |
| **N of Valid Cases** | | 1320 | |

**Table 10** summarizes the inferential statistical test results per task.

**Table 10.**

**Inferential statistics for the Task Difficulty.**

| Task | Chi-squared | *p* | Cramer's V | *p* |
|---|---|---|---|---|
| **T1 To identify** | 25.31 | 0.000 | 0.459 | 0.000 |
| **T2 To find extreme values** | 20.34 | 0.000 | 0.412 | 0.000 |
| **T3 To distinguish** | 15.893 | 0.000 | 0.364 | 0.000 |
| **T4 To retrieve values** | 13.738 | 0.001 | 0.338 | 0.001 |
| **T5 To compare** | 14.25 | 0.001 | 0.345 | 0.001 |
| **T6 To interpret** | 5.974 | 0.05 | 0.223 | 0.05 |
| **T7 To categorize** | 8.956 | 0.011 | 0.273 | 0.011 |
| **T8 To group** | 18.551 | 0.000 | 0.393 | 0.000 |
| **T9 To sort** | 12.345 | 0.002 | 0.321 | 0.002 |
| **T10 To associate** | 9.754 | 0.008 | 0.285 | 0.008 |
| **T11 To locate** | 7.067 | 0.029 | 0.243 | 0.029 |
| **DIFFICULTY** | 125.282 | 0.000 | 0.308 | 0.000 |

It shows that almost all of the tasks are significant, except for T6 To interpret. Its chi-square was 5.974, whereas that of the other ten tasks was higher than 5.9915. Therefore, the chi-square value of T6 was smaller than 5.9915, indicating a failure to reject Ho. Moreover, the p-value derived from both chi-squared and Cramer's V tests was equal to 0.05, confirming the chi-squared test results for T6. Overall, there is no correlation between map type and the difficulty of interpreting a particular object portrayed on the map.

### 4.4. Spatial Distribution

Spatial distribution of map reading results is very important for the education and public health sectors in order to effectively solve problems in the area and find ways to prevent the spread of the epidemic. **Fig. 7** shows the different result between choropleth map reading (top) and graduated symbol map reading (bottom). Both are presented in choropleth map.

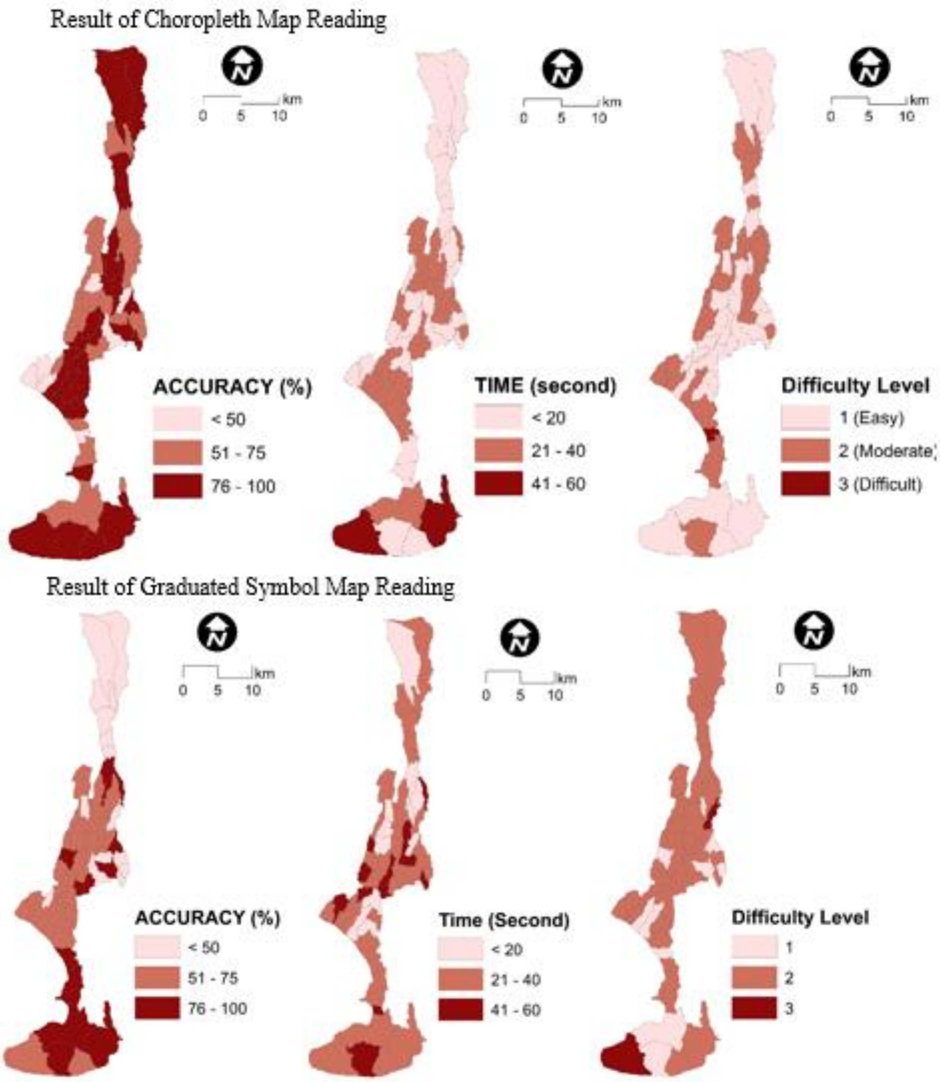


**Fig. 7.** Distribution of Map Reading Results Presented in Choropleth Map. Top: Result of Choropleth Map Reading. Bottom: Result of Graduated Symbol Map Reading.

The results show that, spatially, people have better accuracy, time and difficulty levels when reading choropleth maps. Respondents in the southern region of Badung Regency answered with an accuracy of more than or equal to 76%. This result can be related to the condition of the southern area which is a tourism location, so that people are more accustomed to reading maps or using maps. Very few areas had less than 50% accuracy and spent more than 40 seconds when reading the Chropleth map. Respondents also chose the choropleth map as a map that is easier to read, indicated by a lower level of difficulty than the graduated symbol map.

Meanwhile, reading a graduated symbol map shows results that are not as good as reading a choropleth map. In general, this can be caused by people who are not used to reading graduated symbol maps. This can be seen from the distributions of respondents who answered with poor accuracy, spent more time and experienced higher level of difficulty.

## 5. DISCUSSION

The correlation analysis between map type and the accuracy of the answer showed different results for all map-reading tasks. The descriptive analysis revealed that the public is able to find location points on both the choropleth and graduated symbols maps (T11). This statement is true for the public's ability to find extreme values (T2), compare (T5), categorize (T7), group (T8), sort (T9), and associate (T10). Although there are only slight differences in the ability to read both maps, the map reading accuracy is better for the choropleth map. In contrast, significant differences are observed in the ability to distinguish (T3), retrieve values (T4), and interpret (T6) data on the map. In this case, the public exhibits a better ability to complete these tasks on the choropleth map. This statement is confirmed by the statistical results, i.e., chi-square values, p-values, and Cramer's V values, which indicate a strong correlation between map type and the accuracy of the answer provided to distinguish, retrieve values, and interpret map objects. Overall, the choropleth map is considered capable of presenting the best results in terms of accuracy.

Based on the second aspect, the average time the public requires to complete each task on the choropleth map is 28.15 seconds. However, it takes a longer time for the public to finish the same question or command on the graduated symbols map, i.e., 35.78 seconds. Statistically, they can quickly identify (T1), retrieve values (T4), compare (T5), interpret (T6), group (T8), and locate (T11) information on the map.

As for the third aspect, more respondents (54%) find that it is easy to read the choropleth map, whereas fewer (25%) perceive the graduated symbols map as easy to read. These findings are supported by the statistical analysis results, which indicate that almost all tasks are significant, except for T6 To interpret. However, T6 does not give a statistically significant effect on the overall measurements for the difficulty of the map-reading tasks because its p-value is very low. The choropleth map is considered easier to read in terms of identifying (T1), finding extreme values (T2), differentiating (T3), retrieving values (T4), comparing (T5), categorizing (T7), grouping (T8), sorting (T9), associating (T10), and locating (T11) its information content.

In general, the public answers accurately, takes a shorter answer time, and finds it easy to retrieve values (T4) from both maps. They provide the correct answers and experience little to no difficulty in distinguishing (T3) and interpreting (T6). Further, they require a relatively quick time and experience little to no difficulty in identifying (T1), comparing (T5), grouping (T8), and locating (T11) the information contents of both maps. Lastly, they do not experience a significant challenge in finding extreme values (T2), categorizing (T7), sorting (T9), and associating (T10) particular objects portrayed on the map.

The results of this study indicate that the choropleth map shows the best results for each data analyzed (accuracy, time, and level of difficulty). Based on the statistically significant tasks, it can be summarized in the order of the highest to the lowest: related to the difficulty of the map-reading tasks (10 out of 11 tasks), the answer time (6 out of 11), and the accuracy of the answers (3 out of 11).

A research from Słomska-Przech and Galebiowska (2021) shows that when it comes to the overall results, the best metrics of performance (answer accuracy and time) for all tasks were obtained when working with the choropleth map. It means that choropleth map was used in many tasks and field of study, not only in Indonesia but also abroad. Similar task and methodology were also used by Słomska-Przech, Panecki & Pokojski, (2021) who compared the usability of heat maps with different levels of generalization. The objective (the correctness of the answer, response times) and subjective (response time self-assessment, task difficulty, preferences) metrics were measured. The tasks for map reading were used widely and were able to measure the benefits of the map by giving tasks to the map reader. It is worth comparing the effectiveness of numbers on maps with other methods of data presentation–for example, heat maps, isopleths, etc (Korycka-Skorupa & Gołebiowska, 2020).

## 6. CONCLUSIONS

The average accuracy or correctness of the answer for the choropleth and graduated symbols maps is 73% and 63%, respectively. For the first aspect (i.e., difficulty level), 54% of the respondents claim that it is easier to read the choropleth map, whereas 25% perceive the graduated symbols map as easy to read. The average time required to read and answer each question or command on the choropleth map is 28.15 seconds, which is faster than completing the same task on the graduated symbols map (35.78 seconds). In other words, it takes more time to answer questions or respond to commands using the graduated symbols map.

Based on the analysis results for the three aspects (accuracy, time, and level of difficulty), it appears that the choropleth map is easier to understand. Each has been analyzed for their correlations with map type as the subsets of the map-reading ability. The hypothesis tests revealed that there is a correlation between map type and the public's ability to understand the map based on accuracy, task difficulty, and answer time.

This study shows that the choropleth map becomes an effective and preferred map for understanding information about COVID-19. The choropleth map is considered the easiest solution to map spatial phenomena related to COVID-19. This condition may have positive and negative sides. On the one hand, choropleth maps are a powerful way of presenting spatial data. On the other hand, the creation of choropleth map must be done carefully to avoid mistakes. The use of the map depends on the purpose and the problem to be solved. Therefore, mappers cannot restrict the use to one type of map and may not ignore other types of maps. Research related to cartography, must pay attention to every type of map.

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