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Method of Successive Interval in Community Research (Ordinal Transformation Data to Interval Data in Mathematic Education Studies)

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Abstract: **This paper seeks to explain the scale of measurement and the transformation of the ordinal scale to distance scale by using the Method of Successive Interval (MSI). In addition, in this paper demonstrated a statistical difference in the groups of test results before the data transformation and after transformation by using MSI. Using statistical tests on group data before and after transformation raises interpretation distinction. Oversight in selecting statistical test will lead to wrong interpretation as well. Therefore, it is required accuracy in selecting test statistic in a study. Data obtained from measurements using an ordinal scale should be tested with a non-parametric statistics. However, if you want to use parametric statistics, the transformation of the ordinal scale to scale the distance (interval) should be done first.**

Keywords: **measurement, transformation, ordinal, interval, successive.**

1. INTRODUCTION

Data analysis is interpreted as an effort to process data into information, so that the characteristics or attributes of the data can be easily understood and will be helpful to answer the problems associated to the research activities. Thus, data analysis techniques can be interpreted as how to implement an analysis of the data, with a purpose to process the data into information. Therefore, the characteristics or attributes of the data can be easily understood and will be helpful to answer the problems that related to the research activities, either it is related to the data information or to make an induction, or draw conclusions about the population characteristics (parameters) based on the data from sample (Sudjana, 2005; Anas, S., 2008; Dajan, A., 2009: Garrett, H.E., 2007).

Data analysis techniques are divided into two, the descriptive data analysis techniques and inferensial data analysis techniques. Data analysis techniques in descriptive study is done by descriptive statistics, the statistics used to analyze the data by describing or illustrating how the data were collected just as they are without the any purpose to generalize the findings. Included in the descriptive statistical data analysis techniques are presenting data in tables, diagrams, frequency, and percentages. Meanwhile the techniques of data analysis are done by statistical inferensial inferensial, where the statistics is used to analyze data by making a general conclusion. Thus, the inferensial statistical work for colligate sample findings to the population. If it is compatible with the functions, then the inferensial statistics is suitable for the study sample (Sudjana, 2005; Anas, S. 2008; Dajan, A., 2009: Garrett, H.E., 2007).

One of the elements that form the basis in scientific research is the measurement. Everything we do starts with the measurement of objects that will we learn. Measurement is by giving number or code for an object. Simply, measurement is defined as a procedure to classify the case (the subject of research, experimental units, the respondent, or in general objects such as people, companies, objects, and so on) into the categories within a particular variable. The expression indicates that variable is closely associated with the notion of measurement. Variebel is any characteristic that can be classified into at least two classifications (Gay, LR, Milss, GE, & Airasian, P., 2006; Badru, BB, 2010; Somekh, B., & Lewin, C., 2007; Creswell, JW, 2008; Indriantoro & Supomo, 2001; Sugiyono, 2004; Moses, MS, 2007; and Nazir, Moh., 2003).

In quantitative studies, for example when a student wants to use parametric statistical regression analysis to analyze and assess research problems. Selection of model analysis is commonly used only when the scale of measurement that is done is an interval or ratio. Meanwhile the data collection techniques are performed by students is an ordinal scale. In facing such situation, one way to do is by raising the level of ordinal measurement scale into intervals. Perform data manipulation by increasing the ordinal scale into interval, besides not to breaking the norm, is also to change the terms so that the normal distribution can be fulfilled when using parametric statistics. One transformation method which frequently used is *Method of Successive Interval* (MSI) (Arikunto, S., 2005; Anwar, S., 2004; Sudjiono, A., 2005; Umar, H., 2002; Simamora, 2004; Linn & Gronlund, 2000).

In the following description will explain about the measurement scale and the ordinal scale transformation to the distance scale by using *Method of Successive Interval* (MSI).

2. MEASUREMENT SCALE

The measurement scale is an agreement that is used as a reference for determining the length of the short interval in measuring instruments, so that the measuring instrument when used in the measurement will produce quantitative data. With the scale of these measurements, the values of variables measured with a specific instrument can be expressed in terms of numbers, so it would be more accurate, efficient and communicative. There are four types of measurement scales, which are; Nominal, Ordinal, Interval and Ratio (Gay, L.R., Milss, G.E., & Airasian, P., 2006; Badru, B.B, 2010; Somekh, B., & Lewin, C., 2007; Creswell, J.W., 2008; Indriantoro & Supomo, 2001; Sugiyono, 2004; Musa, M.S., 2007; dan Nazir, Moh., 2003).

1. Nominal Scale:

Nominal scale is a measurement scale that states category, or group of a subject. Which means, the variables measured in terms of whether the characteristics of an object can be distinguished from other karakateristik, but we can not measure or even sort the rankings of these categories (Badru, B.B, 2010; Somekh, B., & Lewin, C., 2007; Creswell, J.W., 2008; Indriantoro & Supomo, 2001; Sugiyono, 2004; Musa, M.S., 2007; dan Nazir, Moh., 2003).

Therefore it is not appropriate to calculate the average value and standard deviation of the variable gender. Figures 1 and 2 are only as a way to classify subjects into different groups or just to calculate some number in each category. So, the test statistic that respons to the nominal scale is a statistical test that is based on counting such as mode and a frequency distribution (Gay, L.R., Milss, G.E., & Airasian, P., 2006; Badru, B.B, 2010; Somekh, B., & Lewin, C., 2007; Creswell, J.W., 2008; Indriantoro & Supomo, 2001; Sugiyono, 2004; Musa, M.S., 2007; dan Nazir, Moh., 2003).

2. Ordinal Scale:

Ordinal scale not only categorized variable into groups, but also ranks the category. In other words, the ordinal scale allows us to sort the ranks of the object that we measured. In this case we can say that A is "much better" than B, or B is "less good" than A, but we can't say how much A is more than B. By that, the limit of one variation of the value to another is not clear. It only can be compared only if the value is higher, equal, or lower than the others, but we can't say certain difference the distance (interval) between these values (Gay, L.R., Milss, G.E., & Airasian, P., 2006; Badru, B.B, 2010; Somekh, B., & Lewin, C., 2007; Creswell, J.W., 2008; Indriantoro & Supomo, 2001; Sugiyono, 2004; Musa, M.S., 2007; dan Nazir, Moh., 2003).

Ordinal scale is one type of scale that is widely used in social research. However, frequently testing statistical errors appear that associated with these scales (Ruslan, 2008; Paelori, T., 2006; Abadi, A.A., 2006; Hisyam, 2010; Bandi, 2010; Badru, B.B., (2010); dan Irvan, M., 2010).

For example in the measurement of performance perceptions levels, each question item are numbered 1 for strongly disagree statements, 2 for disagree statements, number 3 for the in doubt statement, number 4 for agreed statement, and

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points score for the statement that could not agree more. Respondents who chose the number 4, it doesn't mean his perception of the performance on the item in question is 2 times than people who choose number 2. On the other hand, it also doesn't mean that a respondent who chose number 4 has the same perceptions with the respondents who chose the number 1, plus the perception of respondents who chose number 3. This is because the mathematical operations are only valid on ordinal scale and limited to the operation "=", "≠", "<" and "> '.

In order to make sure the ordinal scale can be used in data analysis using statistical parametric, first of all the data transformation will be done by using the Method of Successive Intervals (MSI). The probability transformation of "Z" is done to intervalized options on each item, or by using Weight Factor Score (Ruslan, 2008 ; Paelori, T., 2006; Hisham, 2010; Badru, BB, (2010); and Irvan, M., 2010). Because of changing the ordinal scale into an interval with MSI and Z transformation method takes long time and the level of errors in performing the calculations is high enough, then the score factors may be the best alternative.

3. Interval Scale:

Interval scale not only allows us to classify, sort ranks, but also to measure and compare the size difference between the value (Gay, L.R., Milss, G.E., & Airasian, P., 2006; Badru, B.B, 2010; Somekh, B., & Lewin, C., 2007; Creswell, J.W., 2008; Indriantoro & Supomo, 2001; Sugiyono, 2004; Musa, M.S., 2007; and Nazir, Moh., 2003).

Besides the calculation of the median, mode, and the percentage, the calculation of average, standard deviation, and range can already be used on a interval scale. It is because the mathematical operations that can be used on a scale interval is the sign "=", "≠", "<", ">", "+", "-" "x", and "÷". For example the temperature: 10 ° C + 40 ° C = 50 ° C. Thus, on interval scale can already be used with a statistical parametric testing, but before that the normality of the data has to be test first.

4. Rasio Scale:

Ratio scale is very similar to the interval scale; besides it already have all the properties of the interval, is also identifiable absolute zero point, thus allowing states the ratio between these two values, such as x is two times as y. Some examples are weight, height, length, and age. For example, A = 70 kg weight, the weight W = 35 kg, Weight C = 0 kg. Here we can compare the ratios, for example, we can say that the weight of A is two-times the weight of B. Weight C = 0 kg, means that C doesn't have weights. Number 0 here is clear and indicates absolute value of 0. It is quite difficult to distinguish between interval and the ratio scale. The key is number 0, but the question is; does the value of zero is absolute (has meaning) or not? For example, the temperature can be in interval scale and also in ratio scale, depends on the scale of measurement that used. If we use the Celsius or Fahrenheit scale, it will included in interval scale, meanwhile if Kelvin is used, it will included in ratio scale. Why? It is because the temperature of 0 degrees Kelvin is absolute! We're not only can say that the temperature of 200 degrees is higher than the temperature of 100 degrees, but we also can certainty stated that the ratio is two times higher.

Besides calculation median, mode, and percentage, the calculation of average, standard deviation, and range can also be used in ratio scale. The sign that can be used in mathematical operations of interval scale are "=", "≠", "<", ">", "+", "-" "x", and "÷". Thus, statistical parametric testing can already been used on ratio scale, but before that the normality of the data have to be tested first.

3. METHOD

Ordinal scale to distance scale transformation is done by using Method of Successive Interval (MSI). This method done by calculating the proportion of each option on the scale that is used, then find the appropriate value in proportion to the normal diepersion. By using the MSI, besides doing transformation from ordinal scale to the distance scale, it is also by transformating the data to have normal dispersion. Therefore, parametric statistical test can be used (Waryanto, B., and Milafati, YES, 2006).

Transformation of ordinal scale to distance scale with the MSI performed on each option of each question items (Waryanto, B., and Milafati, YES, 2006). Stages in doing transformation with MSI are:

1. Determine the frequency on each option of each question items
2. Determine the proportion of each option by dividing the frequency of choice by the number of samples

3. Calculate the cumulative proportion that is by summing the proportion sequentially for each option
4. Determining the value of Z for each cumulative proportion that is considered follow the standard normal distribution
5. Determining the Density values for each value of Z
6. Counting Scale Value (SV) for each option
7. Changing the smallest Scale Value (SV) to be equal with one (1) and transforming each scale according to the smallest scale changes in order to obtain Transformed Scale Value (TSV).

Example:

Suppose a student has the choice of instrument with each item question, namely: strongly agree, agree, neutral, disagree, and strongly disagree. Each option is given as an attribute score, that is; strongly agree = 5, agree = 4, neutral = 3, disagree = 2, and strongly disagree = 1. Number of sample study is 100 people.

For question 1, the data that obtained are; 23 people chose strongly agree, 55 people chose agree, 12 people chose neutral, 6 people chose not to agree, and 4 people chose strongly disagree.

Work Steps:

1. Determine the frequency of each option

Based from the data obtained, the frequencies of each option are:

- Strongly disagree = 4
- Disagree = 6
- Neutral = 12
- Agree = 55
- Strongly agree = 23

2. Determine the proportion of each option by dividing the frequency of choice with number of samples

- Proportion of stongly disagree option (P1) = 4/100 = 0.04
- Proportion of disagree option (P2) = 6/100 = 0.06
- Proportion of neutral option (P3) = 12/100 = 0.12
- Proportion of agree option (P4) = 55/100 = 0.55
- Proportion of stongly agree option (P5) = 23/100 = 0.23

3. Calculate the cumulative proportion of that is by summing the proportion sequentially for each option

- PK1 = 0.04
- PK2 = 0.04 + 0.06 = 0.10
- PK3 = 0.10 + 0.12 = 0.22
- PK4 = 0.22 + 0.55 = 0.77
- PK5 = 0.77 + 0.23 = 1.00

4. Determining the value of Z for each cumulative proportion that considered spread follow the standard normal distribution. Z values can be seen on the Table of a normal Z distribution. If the desired value of Z is not found in the Table, then the linear interpolation or by taking the closest value can be done. Z value for each cumulative proportion is the distance from the midpoint of the normal curve Z to respective cumulative proportions, as shown in the following figure:

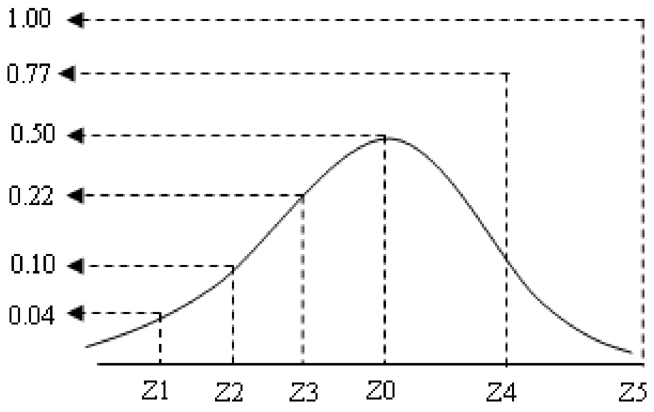

Figure 2: Z Values in Normal Curve

5. For PK1 = 0.04, the area of the Z0 to Z1 = PK1 - 0.5 = -0.46 (negative sign indicates that the Z1 located on the left Z0).

In the table Z distribution, the size area 0:46 is not in the Table, therefore the closest size area that chosen is 0.46080. Z value that corresponds to the size area 0.46080 is 1.76. Therefore the value Z1 = -1.76

6. Next, the value of Z2, Z3, Z4, and Z5 for each PK2, PK3, PK4, and PK5 are obtained in the same way. The result is:

Z2 = –1.29

Z3 = –0.78

Z4 = 0.74

Z5 = ~ (unlimited)

7. Determining the Density values for each value of Z. Density values can be seen in the normal curve size Table (see Table 1). Density values are in the "ordinate (y)" colomn.

Z1 = –1.76 ➔ DZ1 = 0.08478

Z2 = –0.29 ➔ DZ2 = 0.17360

Z3 = –0.78 ➔ DZ3 = 0.29431

Z4 = 0.74 ➔ DZ4 = 0.30339

Z5 = ~ ➔ DZ5 = 0

8. Calculating *Scale Value* (SV) for each option:

$$SV = \frac{Density\ lower\ limit\ value - density\ upper\ limit\ value}{suitable\ cumulative\ proportion - underneath\ cumulative\ proportion}$$

$$SV1 = \frac{0-0.08478}{0.04-0} = -2.1195$$

$$SV2 = \frac{0.08478-0.17360}{0.10-0.04} = -1.4803$$

$$SV3 = \frac{0.17360-0.29431}{0.22-0.10} = -1.0059$$

$$SV4 = \frac{0.29431-0.30339}{0.77-0.22} = -0.0165$$

$$SV5 = \frac{0.30339-0}{1.00-0.77} = 1.3191$$

9. Changing the Scale Value (SV) to be equal to one (1) and transforming each scale according to the smallest scale changes in order to obtain Transformed Scale Value (TSV).

The smallest SV is SV1 = -2.1195. To transform SV1 to be equal to one (1), then 3.1195 needs to be added. The other each SV value are also added 3.1195.

TSV1 = –2.1195 + 3.1195 = 1.0000

TSV2 = –1.4803 + 3.1195 = 1.6392

TSV3 = –1.0059 + 3.1195 = 2.1136

TSV4 = –0.0165 + 3.1195 = 3.1030

TSV5 = 1.3191 + 3.1195 = 4.4386

TSV values above sequentially are the result of transformation from the ordinal scale to the distance (interval) scale. The results are shown in the following table.

Table 1: Transformation Results from the Ordinal to Interval Scale for Question Item 1

Options	Before Transformation (ordinal scale)	After Transformation (interval scale)
Strongly disagree	1	1.0000
Disagree	2	1.6392
Neutral	3	2.1136
Agree	4	3.1030
Strongly agree	5	4.4386

Transformation Scale process in question item 1 above, also performed on other question items. Thus the data that obtained after performing the transformation is the interval data, so it is allowed to use the parametric statistics.

4. FINDING: STATISTICS DIFFERENCES TEST RESULTS BEFORE AND AFTER TRANSFORMATION

Suppose a student conduct a study using sample of 100 people. Data independent variable (X) is obtained from about 8 question items, and data-dependent variable (Y) obtained from 9 question items. X and Y data before transformation were each given symbol X_{early} and Y_{early}, and symbol X_{trans} and Y_{trans} given after transformation. Kind of test that will be used is the Linear Regression.

Results after processed with SPSS 17 are shown by the following Table:

Linear Regression Test for the data before transformed:

Table 2: Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	7.545	1.522		4.958	.000
	X_{early}	.784	.047	.861	16.761	.000

a. Dependent Variable: Y_{early}

Table 3: Summary Model

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.861[a]	.741	.739	3.39915

a. Predictors: (Constant), Xearly

Linear Regression Test for the data after transformed:

Table 4: Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	6.943	1.485		4.676	.000
	X_{trans}	.882	.059	.834	14.980	.000

a. Dependent Variable: Y_{trans}

Table 5: Summary Model

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.834[a]	.696	.693	3.58735

a. Predictors: (Constant), X_{trans}

From the Table 2, 3, 4 and 5 above, some of the following can be stated:

1. Either the data before or after the transformation indicates a significant effect (see Table 2 and 4 column sig.)

2. There is regression coefficient's difference (see Table 2 and 4)

- Constant regression (B0) on table 2 is 7.545 while in table 4 is 6.943. These results provide differrent interpretations, that is: table 2 shows that the score of the dependent variable (Y_{early}) is ***7.545*** by ignoring the independent variable (X_{early}). While in table 4, the dependent variable's score (Y_{trans}) is ***6.943*** by ignoring the independent variable (X_{trans}). There is a difference score that is ***0.602***. This indicates that there are different interpretations in the two groups of data (before and after transformation).

- Regression coefficient (B1) on table 2 is 0.784, while in table 2 it is 0.882. These results provide differing interpretations as well, that is; Table 2 shows that each increase of ***1*** unit on X_{early} variables will lead to an increase in ***0.784 units*** on the Y_{early} variable. While in Table 4, each ***1*** unit increase on X_{trans} variable will be followed by an increasing of ***0.882 units*** in Ytrans variables. This shows that there is distinction interpretation on both data groups of (before and after transformation), with difference of ***0.098***.

3. There is difference in correlation coefficient value and coefficient of determination (degrees determinants) as in schedule 3 and 5.

- Correlation coefficient value in table 3 is 0.861, while in table 5 the value is 0.834.

- In table 3, the determination coefficient value (r^2) of X_{early} variable to Y_{early} is ***0.741***, which shows the variability that occurs on Y_{early} can be explained by X_{early} variable about ***74.1 percent***. Meanwhile in Table 5, the determination coefficient value (r^2) of X_{trans} to Yrans about ***0.696***, yang menunjukkan bahwa keragaman yang terjadi pada peubah Y_{trans} can be explained by X_{trans} variable about ***69.6 percent***. It shows that there is distinction interpretation of degrees determinant in both data groups (before and after transformation) with difference of ***4.5 percent.***

From the description above it can be said that the use of statistical tests on the data before and after transformation will lead to a distinction interpretation. Oversight in selecting statistical test will lead to wrong interpretation anyway. Therefore, it is required a careful selection of test statistics in study.

Data obtained from measurements using an ordinal scale should be tested with a non-parametric statistics. However, if you want to use parametric statistics, the transformation of the ordinal scale to scale the distance (interval) should be done first.

5. CONCLUSIONS

1. The measurement scale is an agreement that used as a reference to determine the length of the interval in measuring instruments, so it will produce quantitative data when it used in the measurement.

2. There is four types of measuring scale that are Nominal, Ordinal, Interval and Ratio.

3. Ordinal to distance scale transformation is done by using *Method of Successive Interval* (MSI). This methode count every proportion of option in each scale that used, then find appropriate value with the proportion at normal distribution. By using MSI, besides doing transformation from ordinal scale to distance scale, it is also transforming the data until it have normal distribution. By that, the parametric statistic test can be used.

4. Transformating ordinal scale to distance scale by using MSI is done to each option of question items.

5. Using statistic tests on each data group before and after the transformation lead the distinction interpretation. Oversight in choosing statistic test will also lead to wrong interpretation. Therefore, accuracy in choosing a statistic test for a study is needed.

6. Data obtained from measurements using an ordinal scale should be tested with a non-parametric statistics. However, if you want to use parametric statistics, the transformation of the ordinal scale to scale the distance (interval) should be done first.

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