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Assessment of Measures of Central Tendency and Dispersion Using Likert-Type Scale

Yaska, Mutah; and Nuhu, Bata Malgwi

Department of Mathematics and Statistics, Federal Polytechnic, Mubi, Adamawa State, Nigeria.

Corresponding author: batamalgwi2006@gmail.com

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Abstract

This research aims to analyzing measures of central tendency (mean, median, and mode), and measures of dispersion (variance and standard deviation) and to graphically present the simulated data using Likert scale measurement. Mean (μ), Median (Md), Mode (Mod), Variance (σ^2), and Standard deviation (σ) have been calculated on simulated data using 5 and 4 points Likert scales with four different statements. Data analysis is key in any development especially when there is need to understanding people's opinions on a particular issue that has attracted the attention of a specific population. Likert scale of measurement is one of the methods that use statement problems in collecting statistical data in which the respondent agrees with the opinion or disagrees. Considering the 5-point Likert scale, the measure of dispersion in which statement two had the highest standard deviation of 1.53 and the mean value of 2.35 being the least of the mean values implies the significant spread of the data across opinions. Statement one of the 4-points Likert scale has two modes (bimodal) where the opinions "Strongly Agree" and "Agree" have ties of 20 responses each. This implies that interpretation of such data may be difficult, because the data can be roughly split into two different groups, and can be useful for further research to find a mode to draw conclusions. The best form of Likert scale can be recommended for 5-point Likert scale so as to give room for undecided opinion. Other measures of central tendency and dispersion can be useful in interpretation but the recommended statistical tool is standard deviation as it shows the spread of the opinions about the mean.

Keywords: Data, Likert, Analysis, Measurement, Opinion.

Introduction

Likert's scale is a measurement method to assess an individual's opinions about specific issues. It might be either bipolar reflecting two opposite states of the responses or unipolar reflecting a regular graduation in the degree or status of the problem being measured. A lot of descriptive studies in educational and psychological research collect data measured on Likert scales. However, there are arguments among researchers about which methods are appropriate for descriptive analysis and interpretation of data from Likert scales. The paper describes the nature of Likert scales and illustrates ways of descriptively analyzing and interpreting data collected using Likert scales, also presenting types of bias in Likert scales, and differentiating between Likert scale and Likert-type items (Alkharusi, 2022).

According to (Tanujaya, Prahmana and Mumu, 2022). The Likert scale is one of the essential rating scales used as a measurement tool in social sciences research, especially in the qualitative approach. Unfortunately, this scale has a great deal of controversy surrounding how data is obtained from Likert questionnaires and the appropriate statistical analysis of these data. A systematic review was performed to address this issue. Research publications from various recognized national and international articles served as research objects. The research provides a comprehensive study of the two perspectives of the rating scales based on measurement experts, statisticians, education researchers, and other practitioners. The experts' opinions, analyses, suggestions, and solutions are obtained from journal articles, proceedings, theses, and books. After reading this article, the reader should be able to know that the accurate Likert scale produces data intervals for social sciences research. However, some requirements must be considered, specifically the composite score, midpoint, and the number of points. If these conditions are implemented, statistical methods, parametric and nonparametric, can be used to analyze the data depending on the research purpose.

Likert scale due to its simple application and understanding among respondent and the popularity among researchers, the old Likert scale have been expanded into many variations of *Likert-type* scales.

It is commonly used as survey instruments for design of experiments such as: measuring employee performance in the workplace (Purdey, 2013), communications research (Ryan, 1980), marketing research (Garland, 1991), mathematical attitudes of elementary students (Adelson, & McCoach, 2010), political opinion research (Raaijmakers, van Hoof, 't Hart, Verbogt, & Vollebergh, 2000), and psychometric research (Kulas and Stachowski, 2013). Its popularity, however, does not necessarily equate to its validity as a data collection method (Johns, 2005). Debates over validity arise from the variations in Likert-type scales in the context of these applications.

The Likert scale is applied as one of the most fundamental and frequently used psychometric tools in educational and social sciences research. Simultaneously, it is also subjected to a lot of debates and controversies regarding the analysis and inclusion of points on the scale. With this context, through reviewing the available literature and then clubbing the received information with coherent scientific thinking, this paper attempts to gradually build a construct around the Likert scale. This analytical review begins with the necessity of psychometric tools like the Likert scale and its variants and focuses on some convoluted issues like validity, reliability, and analysis of the scale (Joshi Joshi, Kale, Chandel and Pal, 2015).

Likert scales are useful in social science and attitude research projects. The General Self-Efficacy Exam is a test used to determine whether factors in educational settings affect participant's learning self-efficacy. The original instrument had 10 efficacy items and used a 4-point Likert scale. The Cronbach's alphas for the original test ranged from 0.76 to 0.90. A 5-item Likert scale was created from this instrument by first adding a "3 = neutral/undecided" option and also by adding five negatively-worded items to the instrument. The instrument was piloted with 20 participants. The Cronbach's alpha for this

pilot study was 0.87. The instrument was subsequently used in a large research study, and the Cronbach's alpha was found to be 0.88. This yielded an instrument that showed strong internal consistency (James, 2011).

Likert's scale is a measurement method developed by Rensis Likert in 1932 to assess individuals' attitudes toward any object (Alkharusi, 2022). Validity of Likert scale is driven by the applicability of the topic concerned; in context of respondents' understanding and judged by creator of the response item (Joshi *et al,* 2015).

Likert scale's type and Cronbach's Alpha analysis in determining the reliability and inter-item consistency of questions regarding the assessment of passengers' satisfaction and service quality of Murtala Muhammed Airport 2. The essence of adopting Cronbach's Alpha coefficient for checking the reliability and internal consistency of Likert-type scales cannot be overemphasized as it does not provide reliable estimates for single items or individual items, but for summated scales or subscales so as to have a known reliability of the items. Likert scale's type is suitable with studies in social and behavioural sciences that have to do with perceptions, attitudes, emotions, opinions, personalities, and descriptions of people's environment. It was revealed from the survey of 114 respondents (air passengers) that the reliability test for statements of thirty-nine airport services blended into five service quality attributes for service quality and passengers' satisfaction was 0.893, and 0.861 respectively. The two Alpha values indicate high reliability of questionnaire instrument and internal consistencies of the five-point Likert-type scales. The research recommended that for every perception study particularly in airport study, the reliability and consistency of the questionnaire instrument enhance the reliability of results (Adeniran, 2019).

A Likert survey question is a specific type of question that collects rank ordered responses to assess levels of satisfaction, quality, importance, agreement, disagreement, or frequency. Often, we are interested in concepts that cannot be easily captured in a dichotomous variable (yes/no) or in a strictly quantitative way. Instead, we expect there is a range of possible levels of our concept of interest (i.e., self-confidence, satisfaction, agreement, sense of belonging), the questions often use a declarative statement followed by a rating scale (Harpe, 2015).

According to Iwona (2016), the variables used in statistical research can be measured on different scales. According to Stevens the most common division of measurement scales distinguish four main types: nominal, ordinal, interval and ratio. The chosen scale of measurement implies further the possibility of applying certain statistical methods. For socio-economic research it is frequent that among independent variables appear variables of a qualitative nature. The study presents the idea of the application of the Likert and Osgood scales for the evaluation and quantification of qualitative variables in the real estate valuation process. Taking into account the fact that the property features used in the process of estimating its value are very often measured on weak scales, this research attempted to apply the aforementioned scales to measure the qualitative features of real estate property. Additionally, all the qualitative data can be expressed only on nominal or ordinal scales. This means that they cannot be uncritically treated as metrical variables and

their measurement scale implies the possible application of mathematical operations and statistical instruments. On the other hand, by analysing the type and the character of the qualitative features of the property, we can observe a substantial connection of such features with the assessment of their level of intensity expressed as a semantic interval or the acceptance level of a given phenomenon. This paper attempts to show how to apply the scales developed to measure attitudes in order to quantify the qualitative features of real estate property in the valuation process and shows the interval character of the data measured by the Osgood scale through comparison among three correlations specific for the mentioned type of scale.

Likert (1932), Likert scales involve the presentation of a set of items related to a certain issue. Each item assesses a unique aspect of the overall issue. An individual is asked to rate his or her feelings, perceptions, opinions, or attitudes in terms of agreement or satisfaction or frequency using a response set consisting of equally spaced numbers accompanied by approximately equally spaced.

Likert data produces data intervals so that statistical operations can be carried out, such as sums, means, median, and mode under measures of central tendency and variance and standard deviations under measures of dispersion. With Likert scale data the mean cannot be used as a measure of central tendency as it has no meaning in some data analysis while others use the mean to judge the rate of response, for example what average is the strongly agree or disagree? The result makes no sense in the interpretation of the result. The most appropriate measure is the mode of the most frequent responses or the median. The best way to display the distribution of responses is to use a bar chart or pie chart.

Data analysis is one of the statistical methods of solving problems in any development such as education, research, business analyses, information and communication, political science, public administration, sciences, engineering, and above all understanding people's opinions on particular issues that have attracted the attention of a particular population. Various methods of data collection have been developed and applied in statistics which among others are questionnaires, interviews, published documents, pilot surveys, census, and many other methods. This method developed questions that are open-ended, closed-ended, or subjective. Likert scale of measurement is one of the methods that use statement problems in which the respondent agreed to the opinion or disagreed, scale is given to each opinion for 4 Points Likert scale such as strongly agreed=1, agreed=2, strongly disagreed=3 and disagreed=4, likewise 3 points, 5 points or more points on the Likert scale depending on the number of opinions This research is to analyze the measures of central tendency and measures of dispersion of Likert scale data.

Statement of the Problem

Data analysis is key in any research development especially when there is need to understanding people's opinions on a particular issue that has attracted the attention of a specific population. Likert scale of measurement is one of the methods that use statement problems in collecting statistical data in which the respondent agrees with the opinion or

disagree. Researchers used Likert scale question as method of data collection, in this research, the paper will explore likert scale as method or tool for analysis not as material for data collection.

Aims and Objectives of the Study

This research aims at analyzing measures of central tendency (Mean, Median and Mode) and dispersion (Variance and Standard deviation) of Likert scale data. The objectives is to simulate data and apply it on five and four Likert Scale statement to determine the mean, median, mode, variance and standard deviation. The outcome will be applied on which measurement is best fit for interpreting the Likert scale data.

Methodology

In this section of the research the data source, size of the sample, statistical tools, graphical presentation, findings, results and recommendations will be explained in details.

Sources of Data and Sample Size

Simulation studies of data was used for the testing of the models or equations, data was simulated at various Likert scale of measurement which include three, four and five opinions of the Likert scale and the statistical tools involves are mean, median, mode, variance and standard deviation. The sample sizes involved in this study are 50, 100, 200 and 300 at various likert scale of measurement which include 4 and 5.

Likert Scale

Consider the table below which indicates a simple Likert scale of the method of data collection.

Table 1: Attitude study of 5 points Likert Scale

Statement:	Statistics as a course should be compulsory in all fields of study				
Opinion:	Strongly Agreed	Agreed	Undecided	Disagreed	Strongly disagreed
Likert scale:	(1)	(2)	(3)	(4)	(5)

The table 1 indicates a common form of statement problem regarding the interest of a population in which each citizen has different perspectives regarding collection of loan and its uses. An individual who strongly believes that the loan will be used judiciously will mark "strongly agreed", some one believes the may be used for a particular sector may agree for the collection and will mark "Agreed" while someone who did not see reason for the collection of the loan will go for "Undecided" and an individual who has the mindset that the loan will not be used for the development of the country will mark "disagreed" option and finally a citizen will strongly disagreed if such viewed the loan as method of corruption.

Table 2: Perspectives study of 5 points Likert Scale

Statement:	Statistical analysis is widely applied in every field of research and survey studies				
Opinion:	Strongly Agreed	Agreed	Undecided	Disagreed	Strongly disagreed
Likert scale:	(5)	(4)	(3)	(2)	(1)

The table 2 implies the reversing order of table 1 whichever is adopted in the study will yield the same result.

Table 3: Likelihood Statement of 4-point Likert scale

Statement:	Statistical analysis if properly applied will yield result in a survey.			
Opinion:	Definitely Won't	Probably Won't	Probably Will	Definitely Will
Likert scale:	(4)	(3)	(2)	(1)

Table 3 is a likelihood statement and has 4-points Likert scale, the respondent either agreed that statistics if properly applied will yield a result or not but still based on the likelihood application of statistics in a survey.

Table 4: Agreement Statement of 4-point Likert scale

Statement:	Statistical result or values can best be interpreted by a Statistician.			
Opinion:	Strongly agree	agree	Disagree	Strongly disagree
Likert scale:	(0)	(1)	(2)	(3)

The arrangement in table 4 is an agreement statement which has 4 point Likert scale that starts with zero, such likert scale can also be applied in any form of survey, but has limitation and effect on analysis of the measures of central tendency and dispersion.

Table 5: Quality Statement of 3-points Likert scale

Statement:	What is your opinion on statistical softwares?		
Opinion:	Good	Fair	Poor
Likert scale:	(3)	(2)	(1)

Table 5 is a good example of determining the quality of a product, policies, bills or act like Performance of statistical software, such will determine if the software is good for various statistical data or can only analyze a specific statistical data.

Table 6: Dichotomous Statement of 2-points Likert scale

Statement:	Can statistical data be analyzed without statistical software?	
Opinion:	Yes	No
Likert scale:	(2)	(1)

Table 6 is a good example of dichotomous statement that has only two opinions, the respondent must agree with one of the opinions as there is no room for undecided, such likert method may not be applied in all survey fields of study.

Mean

The mean of any data set is the average rate of response, in applying Likert scale of analyzing a data the mean value indicates the position of the opinion from the statements under review. In this study the mean value will lie between 1.00 to 4.99 using 5 and 4 points Likert scale, the Likert scale values is the weights, where the value can be round up or truncate to the nearest whole number such value will indicate the rate of responses. For any set of data, there is only one mean.

Mathematically:

$$Mean\ (\mu) = \frac{L_1 n_1 + L_2 n_2 + \cdots + L_k n_k}{n_1 + n_2 + \cdots + n_k} = \frac{\sum_{i=1}^{k} L_i n_i}{N} \quad (1)$$

Where L_i is the likert scale value (weight)

n_i is the total response of a statements (question)

N total number of respondents

Median

The median of a distribution is the middle value (if number of values is odd) or the average of two middle values (if number of values is even) when the measurements are arranged in order of magnitude (ascending or descending order). Invariably, the median may be computed using:

$$Md = \begin{cases} M\left(\frac{n+1}{2}\right), \text{if } n \text{ is odd} \\ \frac{1}{2}\left\{M\left(\frac{n}{2}\right) + M\left(\frac{n}{2}+1\right)\right\}, \text{if } n \text{ is even} \end{cases} \quad (2)$$

Mode

The mode of a set of observation is the most frequent value. A frequency distribution may have one mode (unimodal) or two modes (bimodal) or three modes (trimodal) or many modes (multimodal). In Likert Scale analysis the mode is determine from the option that has the highest respondent and the corresponding Likert scale value is the mode of the statement. Bimodal or trimodal and even multimodal can also be available in Likert Scale of measurement. For instance, if the highest number of respondents is 50 and it tallies with

option "strongly agree" with likert scale "5", then it interprets as the mode is 5 and is "strongly agree" opinion. It is most frequent value in a set of data.

Variance

For an analysis that involves Likert Scale of data collection the formula can be written as:

$$variance = \sigma^2 = \frac{n_1(L_1 - \mu)^2 + n_2(L_2 - \mu)^2 + \cdots + n_k(L_k - \mu)^2}{N} = \frac{\sum_{i=1}^{k}[n_i(L_i - \mu)^2]}{N} \quad (3)$$

where n total response on a particular statement in opinion

L Likert scale associated to the particular opinion

μ mean value of a particular statement

Standard Deviation

Standard deviation is a useful measure of dispersion commonly used to determine how the data varies or disperse from the mean by taken the positive square root of the variance gives the expected value of the standard deviation.

$$Standard\ Deviation\ (\sigma) = \sqrt{\frac{\sum_{i=1}^{k}[n_i(L_i - \mu)^2]}{N}} \quad (4)$$

Data Presentation and Analysis

Data simulated was used for the illustration of the measurements.

Let the opinions in Table 7 be defined as Strongly Agree (SA), Agree (A), Undecided (U), Disagree (DA) and Strongly Disagree (SD)

Table 7: Simulated Data of four Statements with 5-points Likert scale

OPINION	Likert Scale (L_i)	Statement One (S_1)	Statement Two (S_2)	Statement Three (S_3)	Statement Four (S_4)
Strongly Agree (SA)	1	5	40	25	50
Agree (A)	2	18	20	50	90
Undecided(U)	3	10	5	10	105
Disagree (DA)	4	7	15	40	40
Strongly Disagree (SDA)	5	10	15	75	15

Graphical Presentation of Data (Descriptive)

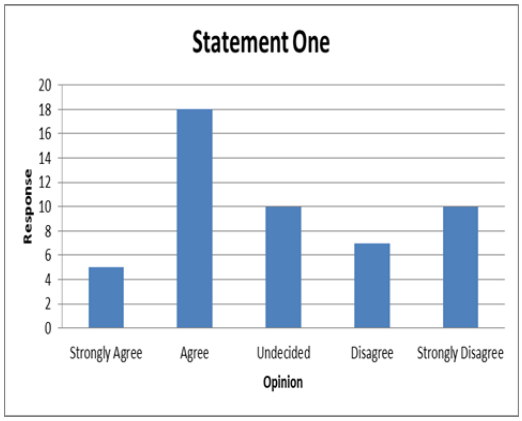

Figure 1: Bar chart showing the levels of responses on 5-points Likert Scale statement

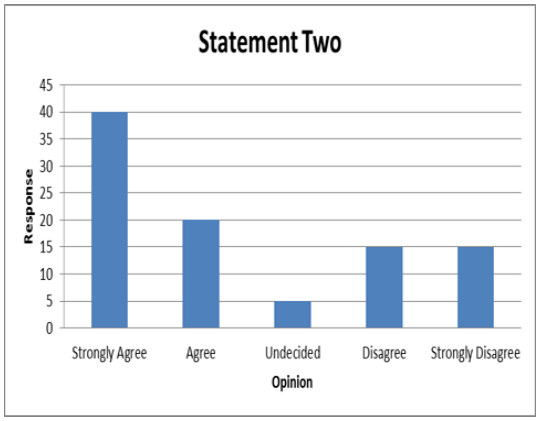

Figure 2: Bar chart showing the levels of responses on 5-points Likert Scale statement

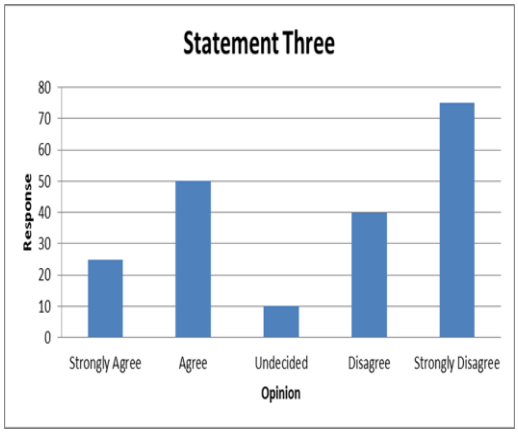

Figure 3: Bar chart showing the levels of responses on 5-points Likert Scale statement

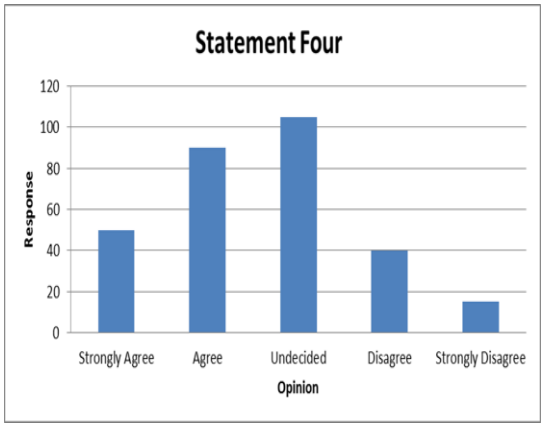

Figure 4: Bar chart showing the levels of responses on 5-points Likert Scale statement

The figures 1 to 4 is the descriptive statistics of the opinions of the respondent, the mode of the statement one is the agree opinion it has the tallest bar and the means majority of the respondent agree with the statement, and statement two has the strongly agree as the mode, like statement three and four have strongly disagree and undecided as the mode respectively.

Table 8: Results of mean, median, mode, variance and Standard deviation of table 7.

OPINION	L_i	S_1	$L_i * S_1$	S_2	$L_i * S_2$	S_3	$L_i * S_3$	S_4	$L_i * S_4$
SA	1	5	5	45	45	25	25	50	50
A	2	18	36	20	40	50	100	90	180
U	3	10	30	5	15	10	30	105	315
DA	4	7	28	15	60	40	160	40	160
SDA	5	10	50	15	75	75	375	15	75
Total		50	149	100	235	200	690	300	780
Mean (μ)		2.98		2.35		3.45		2.6	
Median (Md)		3.04		2.20		4.20		3.35	
Mode (Mod)		2		1		5		3	
Variance(σ^2)		1.7		2.33		2.25		1.14	
Standard dev. (σ)		1.304		1.53		1.50		1.07	

Table 8 indicates the capability of determining the measures of central tendency which include mean, median, and mode from the analysis implying convergence of the data or opinion at the same time, statement two had close mean and median indicating evenly distribution of the opinions. The measures of dispersion indicate absence of outlier or over dispersion. The measure of dispersion which include the variance and the standard deviation, the standard deviation indicated the level of spread of the data away from the mean value in which statement two had the highest standard deviation of 1.53 and the mean value of 2.35 being the least of the mean values implies the significant spread of the data across opinions. The 5-point likert scale can be regarded and suggested as the best compare to 4-point Likert scale statements, this is because it gives room for any audience that has no knowledge of the statement to make choice of undecided.

Table 9: Simulated Data of four Statements with 4-points Likert scale

OPINION	Likert Scale (L_i)	Statement One (S_1)	Statement Two (S_2)	Statement Three (S_3)	Statement Four (S_4)
Strongly Agree (SA)	4	20	50	75	155
Agree (A)	3	20	20	50	90
Disagree (DA)	2	7	15	40	40
Strongly Disagree (SDA)	1	3	15	35	15

Graphical Presentation of Data

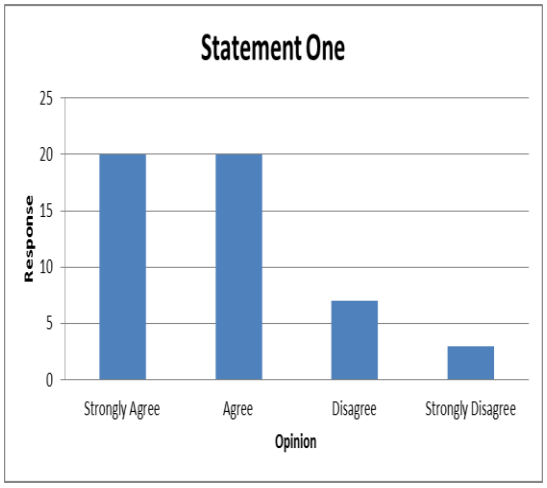

Figure 5: Bar chart on levels of responses on 4-points Likert Scale

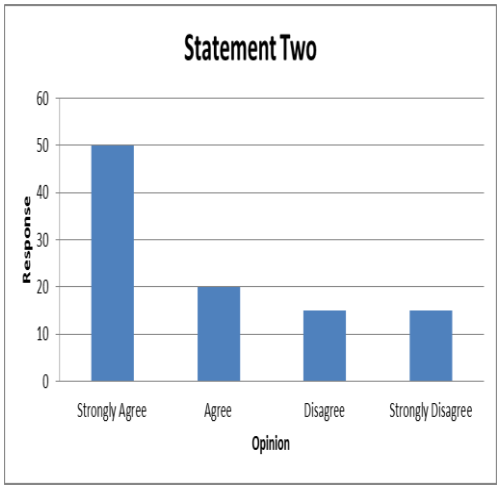

Figure 6: Bar chart on levels of responses of 4-points Likert Scale

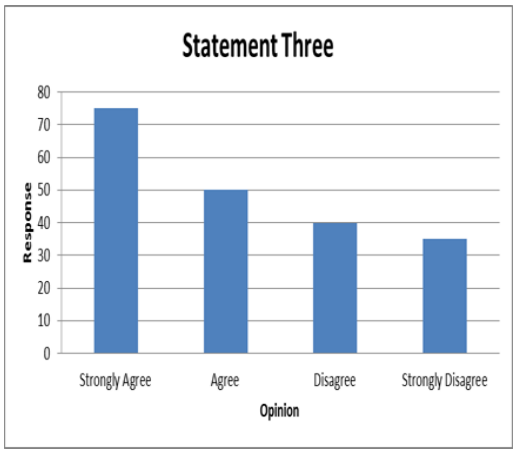

Figure 7: Bar chart showing the levels of responses on 4-points Likert Scale

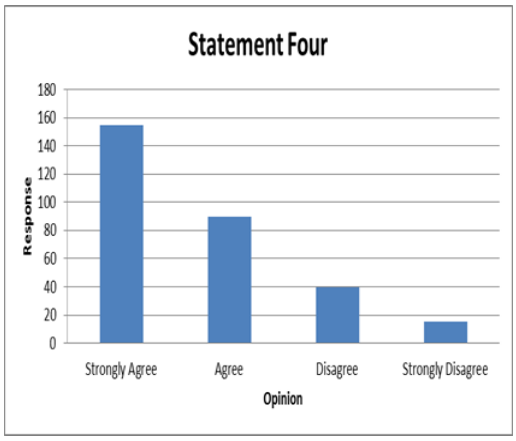

Figure 8: Bar chart showing the levels of responses on 4-points Likert Scale

The figures 5 to 8, displayed the level of responses to each statement, Figure 5 shows that the respondents have ties as the strongly agree and agree show the same level of acceptability, this indicates that there is a bi-mode and such data can be asses further so as to have a simple mode, figure 6, shows that the mode is strongly agree where the mode has more the twice of the other opinions, 50 responses strongly agree with the statement from the simulated data. Figure 7 and 8 of the graphical presentation shows that the modal values are the strongly agree opinion because they are the tallest bar.

Table 10: Results of mean, median, mode, variance and Standard deviation of table 9

OPTIONS	L_i	S_1	$L_i * S_1$	S_2	$L_i * S_2$	S_3	$L_i * S_3$	S_4	$L_i * S_4$
SA	4	20	80	50	200	75	300	155	620
A	3	20	60	20	60	50	150	90	270
DA	2	7	14	15	30	40	80	40	80
SDA	1	3	3	15	45	35	35	15	15
Total		50	157	100	335	200	565	300	985
Mean (μ)		3.14		3.35		2.83		3.28	
Median (Md)		3.4		4.0		3.25		4.0	
Mode (Mod)		4,3		4		4		4	
Variance(σ^2)		0.76		1.34		1.24		0.77	
Standard dev. σ		0.87		1.16		1.16		0.88	

Table 10 results indicate the strength of the measures where statements two and three having the highest standard deviation indicate the clustering of the data at all levels toward the mean and has the highest degree of spread. Statement one has two modes (bimodal) where the opinions "Strongly Agree" and "Agree" have ties of 20 responses each, this implies that interpretation of such data may be difficult. This means that the data can be roughly split into two different groups, the bimodal distribution is useful in identifying two distinct groups that can be used for further research to find a mode to draw conclusion.

Conclusion

In this study, Likert scale measurement is used as method of data collection and was applied, statistical measures of central tendency and dispersion was used as statistical tools which include mean, median, mode, variance, and standard deviation. To demonstrate the performance and analysis of these statistical tools a simulation of data was carried out using 5 and 4 points Likert scale measurement of data collection in which various statements was applied. The best fit statistical tool for analyzing Likert scale is the standard deviation as it displayed the level of convergence of the data around the mean.

Recommendations

- The 5-point Likert scale is suggested as the best fit as it gives room for undecided unlike 4-point Likert scale.
- The standard deviation is suggested as the best tool for analyzing Likert scale method of data analysis as it shows the level of spread of the data toward the mean.
- Graphical presentation should be employed in the study of Likert Scale type of measurement the graph will represent the mode clearly.

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