UNIT 15 NORMAL DISTRIBUTION AND ITS INTERPRETATION

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15.1 INTRODUCTION

So far you have learnt through the Units 12, 13 and 14 respectively, how to organize a distribution of scores and how to describe its shape, central value and variation. You have used histograms and frequency polygons to illustrate the shape of a frequency distribution. You have calculated the measures of central tendency to describe the central value of the frequency distribution. You have also found the measures of variability to indicate its variation.

All these descriptions have gone a long way in providing information about a set of scores. Sometime we need procedures for describing an individual's position in the group, or the cutting points to categorise the group according to the level of ability, or the nature of test paper which a teacher has used to assess the learning outcomes of the students.

For example; suppose a teacher has administered a test designed to appraise the level of achievement and a student has got some score on the test. What did that score mean ? The obtained score had some meaning only with respect to other scores. Sometimes the grades A, B, C, D are assigned to the individuals of a group according to their ability or competency on the basis of scores. For such problems, Normal Probability Curve, which is bell shaped is very helpful.

The present unit presents the concept and use of Normal Distribution in relation to the educational evaluation, by the use of suitable illustrations and explanations.

15.2 OBJECTIVES

After going through this unit, you will be able to:

- explain the concept of Normal Distribution and Normal Probability Curve;
- recall the theoretical base of the Normal Probability Curve;

- write the properties of Normal Probability Curve;
- recognize the various divergence in the normal curve
- recall the definitions of various divergence of Normal Probability Curve
- justify the significance of Skwness and Kurtosis in the educational measurement and evaluation
- interpret the normal curve obtained on the basis of large number of observations
- appreciate the importance of normal curve in educational measurement
- recall the various applications of normal curve in mental measurement and educational evaluation
- read the table of Area under the normal curve
- apply the knowledge of Normal Probability curve in solving the various practical problems related to educational evaluation and mental measurement

15.3 NORMAL DISTRIBUTION / NORMAL PROBABILITY CURVE

15.3.1 The Concept of Normal Distribution

Carefully look at the following hypothetical frequency distribution, which a teacher has obtained after examining 150 students of class IX on a mathematics achievement test (see Table 15.1).

Table 15.1: Frequency distribution of the Mathematics achievement test scores.

Class Intervals	Tallies	Frequency
85-89	I	1
80-84	II	2
75-79	IIII	4
70-74	~~IIII~~ II	7
65-69	~~IIII~~ ~~IIII~~	10
60-64	~~IIII~~ ~~IIII~~ ~~IIII~~ I	16
55-59	~~IIII~~ ~~IIII~~ ~~IIII~~ ~~IIII~~	20
50-54	~~IIII~~ ~~IIII~~ ~~IIII~~ ~~IIII~~ ~~IIII~~ ~~IIII~~	30
45-49	~~IIII~~ ~~IIII~~ ~~IIII~~ ~~IIII~~	20
40-44	~~IIII~~ ~~IIII~~ ~~IIII~~ I	16
35-39	~~IIII~~ ~~IIII~~	10
30-34	~~IIII~~ II	7
25-29	IIII	4
20-24	II	2
15-19	I	1
	Total	150

Are you able to find some special trend in the frequencies shown in the column 3 of the above table ? Probably Yes ! The concentration of maximum frequency (f=30) is at the central value of distribution and frequencies gradually taper off symetrically on both the sides of this value.

If we draw a frequency polygon with the help of the above distribution, we will have a curve as shown in the Fig. 15.1.

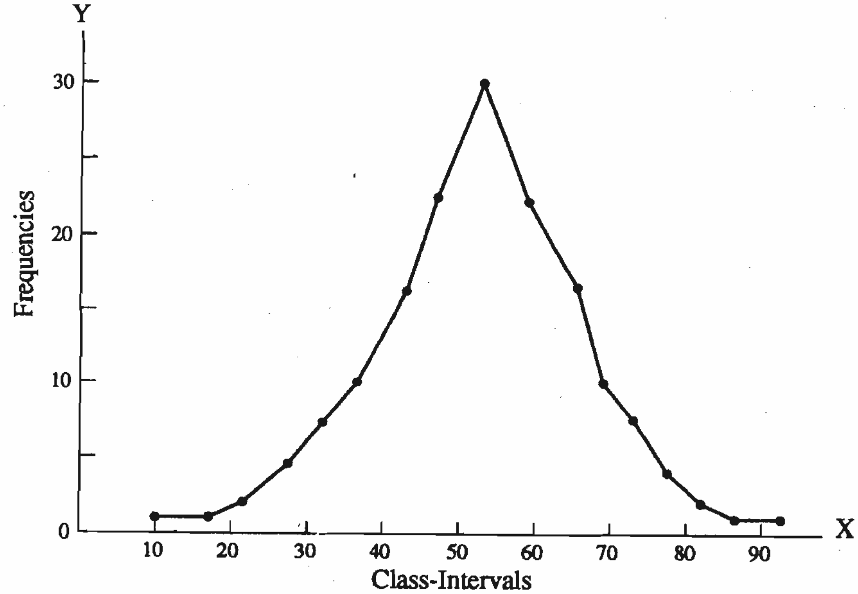

Fig. 15.1 : Frequency Polygon of the data given in Table 15.1

The shape of the curve in Fig. 15.1 is just like a 'Bell' and is symmetrical on both the sides.

If you compute the values of Mean, Mediun and Mode, you will find that these three are approximately the same (M = Md = MO = 52).

This 'Bell' shaped curve technically known as Normal Probability Curve or Simply Normal Curve and the corresponding frequency distribution of scores, having equal values of all three measures of central tendency, is known as Normal Distribution.

This normal curve has great significance in mental and educational measurement. In measurement of behavioural aspects, the normal probability curve has been often used as reference curve.

15.3.2 The Normal Probability Curve : Its Theoretical Base

The normal probability curve is based upon the law of probability (the games of chance) discovered by French Mathematician Abraham Demoivre (1667–1754) in the eighteenth century. He developed its mathematical equation and graphical representation also.

15.3.3 Properties of Normal Probability Curve

The properties of normal probability curve are :

1. The Normal Curve is Symmetrical

The Normal Probability Curve (N.P.C.) is symmetrical about the ordinate of the central point of the curve. It implies that the size, shape and slope of the curve on one side of the curve is identical to that of the other. In other words the left and right values to the middle central point are mirror images, as shown in Figure 15.2 below.

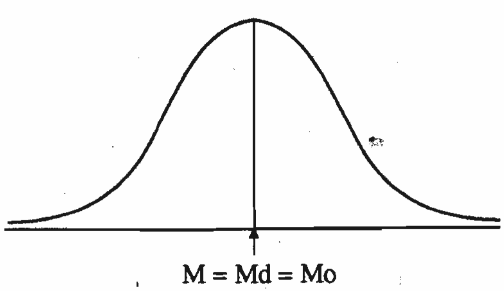

Fig. 15.2

2. The Normal Curve is Unimodal

Since there is only one point in the curve which has maximum frequency the normal probability curve is unimodal, i.e. it has only one mode.

3. The Maximum ordinate occurs at the Centre

The maximum height of the ordinate always occurs at the central point of the curve that is, at, the mid-point.

4. The Normal Curve is Asymptotic to the X-axis

The Normal Probability Curve approaches the horizontal axis asymptotically i.e.; the curve continues to decrease in height on both ends away from the middle point (the maximum ordinate point); but it never touches the horizontal axis. Its ends extend from minus infinity ($-\infty$) to plus infinity. ($+\infty$) as shown in Fig. 15.3.

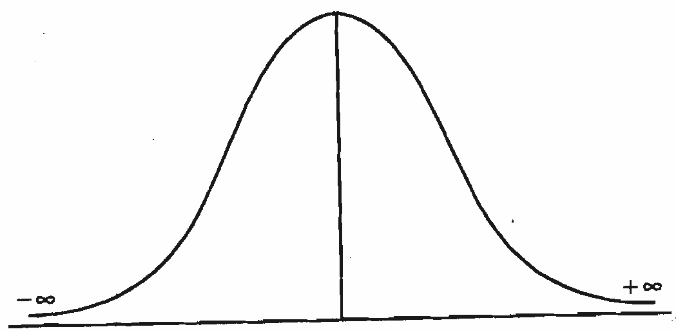

Fig. 15.3

5. The Height of the Curve declines Symmetrically

In the normal probability curve the height declines symmetrically in either direction from the maximum point.

6. The Points of Influx occur at Point ± 1 Standard Deviation ($\pm 1\ \sigma$)

The normal curve changes its direction from convex to concave at a point recognized as point of influx. If we draw the perpendiculars from these two points of influx of the curve on horizontal axis, these two will touch the axis at a distance one Standard Deviation unit above and below the mean ($\pm 1\ \sigma$).

7. The Total Percentage of area of the Normal Curve within Two Points of Influxation is Fixed

Approximately 68.26% area of the curve falls within the limits of ± 1 standard deviation unit from the mean as shown in Fig. 15.4.

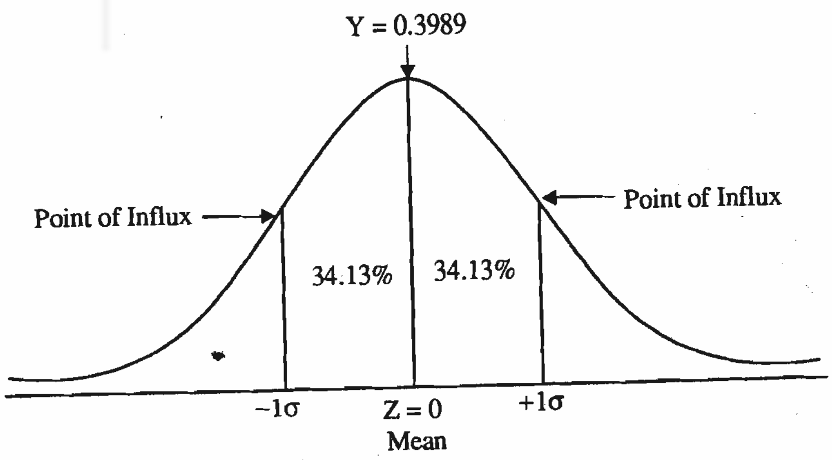

Fig. 15.4

8. The Total Area under Normal Curve may be also considered 100 percent Probability

The total area under the normal curve may be considered to approach 100 percent probability. The area between Mean and any point deviation given in terms of σ – distance is always the same as shown in Fig. 15.5. The percentage area of these distances is known.

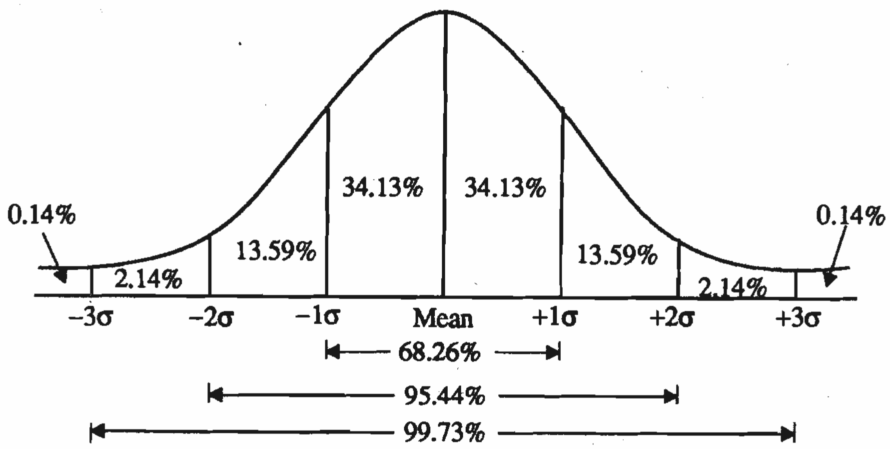

Fig. 15.5 : The Percentage of the cases falling between Successive Standard Deviations in Normal Distribution

9. The Normal Curve is Bilateral

The 50% area of the curve lies to the left side of the maximum central ordinate and 50% lies to the right side. Hence the curve is bilateral.

10. The Normal Curve is a Mathematical Model in Behavioural Sciences

The curve is used as a measurement scale. The measurement unit of this scale is ±σ (the unit standard deviation).

Check Your Progress

1\. i) Define a Normal Probability Curve.

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ii) Mention the properties of Normal Curve.

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iii) State the conditions under which the frequency distribution can be approximated to the normal distribution.

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iv) In a normal distribution, what percentage of frequencies are

a) between – 1 σ to + 1σ

b) between – 2 σ to + 2 σ

c) between -3σ to $+3\sigma$

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v) Practically, why are the two ends of normal curve considered closed at the points $\pm 3\sigma$ of the base line ?

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15.3.4 Divergence in Normality (The Non Normal Distribution)

In a frequency polygon or histogram of test scores, usually the first thing that strikes one is the symmetry or lack of it in the shape of the curve. In the normal curve model, the mean, the median and the mode all coincide and there is perfect balance between the right and left values of the curve. Generally two types of divergence occur in the normal curve.

i) Skewness

ii) Kurtosis

i) Skewness

A distribution is said to be "Skewed" when the mean and median fall at different points in the distribution and the balance i.e. the point of center of gravity is shifted to one side or the other to left or right. In a normal distribution the mean equals the median exactly and there is no skewness.

There are two types of skewness which appear in the Normal Curve.

a) Negative Skewness

b) Positive Skewness

a) Negative Skewness

Distribution is said to be skewed negatively or to the left, when scores are massed at the high end of the scale, i.e. the right side of the curve, and are spread out gradually towards the low end i.e. the left side of the curve. In a negatively skewed distribution the value of median will be higher than that of the value of the mean. Can you think why would it be so ?

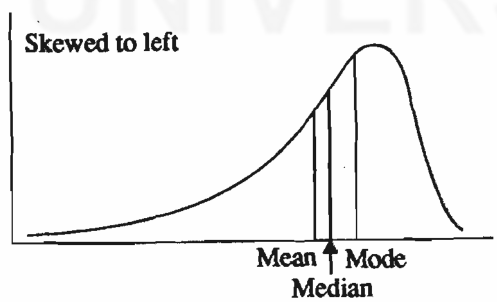

Fig. 15.6: Negative Skewness

b) Positive Skewness

Distributions are skewed positively or to the right, when scores are massed at the low, i.e. the left end of the scale, and are spread out gradually toward the high or right end as shown in the figure below.

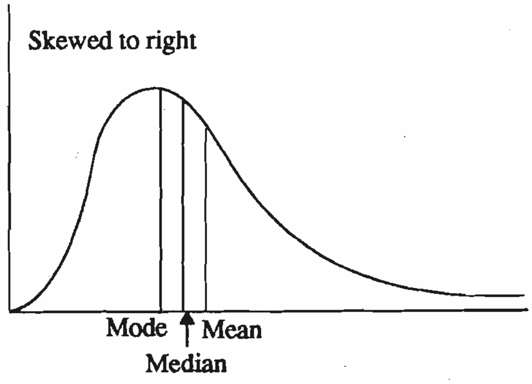

Fig. 15.7 : Positive Skewness

ii) Kurtosis

The term Kurtosis refers to the divergence in the height of the curve, specially in the peakedness. There are two types of divergence in the peakness of the curve.

There are two types of skewness which appear in the Normal Curve.

a) Leptokurtosis

b) Platykurtosis

a) Leptokurtosis

Suppose you have a normal curve which is made up of a steel wire. Suppose you push both the ends of the wire curve together. What would happen to the shape of the curve? Probably your answer may be that by pressing both the ends of the wire curve, the curve become more peaked i.e. its top becomes more narrow than the normal curve and scatterness in the scores or area of the curve shrink towards the center.

Thus in a Leptokurtic distribution, the frequency is more peaked at the centre than in the normal distribution curve.

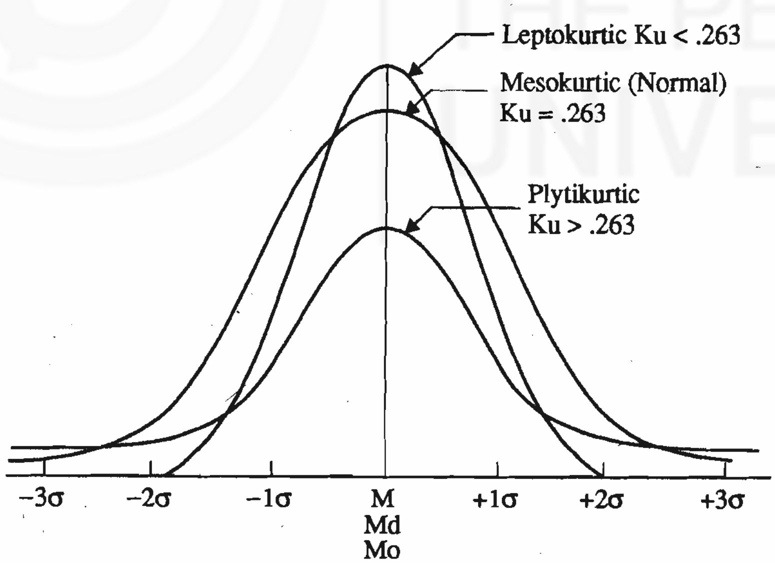

Fig. 15.8 : Kurtosis in the Normal Curve

b) Platykurtosis

Now, suppose we put a heavy pressure on the top normal curve made from the steel wire. What would be the change in the shape of the curve ? Probably the top of the curve would become more flat than that of the normal.

Thus a distribution of flatter peak than of the normal distribution is known as platykurtic distribution.

When the distribution and related curve is normal, the value of kurtosis is .263 (Ku = .263). If the value of the Ku is greater than .263, the distribution and related curve obtained will be Platykurtic. When the value of Ku is less than .263, the distribution and related curve obtained will be Leptokurtic.

15.3.5 Factors Causing Divergence in the Normal Curve/Normal Distribution

The reasons why distributions exhibit skewness and kurtosis are numerous and often complex, but a careful analysis of the data can often throw some light on the asymmetry. Some of the common causes are :

1. **Selection of the Sample**

   Selection of the subjects (individuals) can produce skewness and kurtosis in the distribution. If the sample size is small or sample is biased one, skewness is possible in the distribution of scores obtained on the basis of selected sample or group of individuals.

   The scores made by small and homogeneous group are likely to yield narrow and leptokurtic distribution. Scores from small and highly heterogeneous group yield platykurtic distribution.

2. **Unsuitable or Poorly Made Tests**

   If the measuring tool of test is inappropriate for the group on which it has been administered, or poorly made, the asymmetry is likely to occur in the distribution of scores. If a test is too easy, scores will pile up at the high end of the scale, whereas when the test is too difficult, scores will pile up at the low end of the scale.

3. **The Trait being Measured is Non-Normal**

   Skewness or Kurtosis will appear when there is a real lack of normality in the trait being measured. e.g. interests or attitudes.

4. **Errors in the Construction and Administration of Tests**

   A poorly constructed test may cause asymmetry in the distribution of the scores. Similarly, while administrating the test, unclear instructions, error in timings, errors in the scoring practice and lack of motivation to complete the test may cause skewness in the distribution.

Check Your Progress

2. i) Define the following

   a) Skewness

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   b) Negative and Positive Skewness

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   c) Kurtosis

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d) Platykurtosis

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e) Leptokurtosis

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ii) In case of normal distribution what should be the value of kurtosis ?

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iii) What is the significance of the knowledge of skewness and kurtosis to a school teacher?

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15.3.6 What does Normal Curve Indicate ? (Interpretation of Normal Curve/Normal Distribution)

Normal Curve has great significance in the mental measurement and educational evaluation. It gives important information about the trait being measured.

If the frequency polygon of observations or measurements of a certain trait is a normal curve, it indicates that :

1. the measured trait is normally distributed in the Universe
2. most of the cases are average in the measured trait and their percentage in the total population is about 68.26%
3. approximately 15.87% of (50-34.13%) cases are high in the trait measured
4. similarly 15.87% cases approximately are low in the trait measured
5. the test which is used to measure the trait is good
6. the test has good discrimination power as it differentiates between poor, average and high ability group individuals, and
7. the items of the test used are fairly distributed in term of difficulty level.

15.3.7 Importance of Normal Distribution

The Normal Distribution is by far the most used distribution for drawing inferences from statistical data because of the following reasons :

1. Number of evidences are accumulated to show that normal distribution provides a good fit or describe the frequencies of occurrence of many variable and facts in (i) biological statistics e.g. sex ratio in births in a country over a number of years, (ii) the anthropometrical data e.g. height, weight, (iii) wages and output of large numbers of workers in the same occupation under comparable conditions, (iv) psychological measurements e.g. intelligence, reaction time, adjustment, anxiety and (v) errors of observations in Physics, Chemistry and other Physical Sciences.
2. The Normal distribution is of great value in educational evaluation and educational research, when we make use of mental measurement. It may be noted that normal distribution is not an actual distribution of scores on any test of ability or academic achievement, but is instead, a mathematical model. The distribution of test scores approach the theoretical normal distribution as a limit, but the fit is rarely ideal and perfect.

15.3.8 Applications/Uses of Normal Curve/Normal Distribution

There are number of applications of normal curve in the field of educational measurement and evaluation. These are :

i) to determine the percentage of cases (in a normal distribution) within given limits or scores

ii) to determine the percentage of cases that are above or below a given score or reference point

iii) to determine the limits of scores which include a given percentage of cases

iv) to determine the percentile rank of a student in his own group

v) to find out the percentile value of a student's percentile rank

vi) to compare the two distributions in terms of overlapping

vii) to determine the relative difficulty of test items, and

viii) dividing a group into sub-groups according to certain ability and assigning the grades.

15.3.9 Table of Areas under the Normal Curve

How do we use all the above applications of normal curve in educational measurement and evaluation. It is essential first to know about the Table of areas under the normal curve.

The Table 9.1 gives the fractional parts of the total area under the normal curve found between the mean and ordinates erected at various σ (sigma) distances from the mean.

The normal probability curve table is generally limited to the areas under unit normal curve with $N = 1$, $\sigma = 1$. In case when the values of N and σ are different from these, the measurements or scores should be converted into sigma scores (also referred to as standard scores or Z scores). The process is as follows :

$$Z = \frac{X - M}{\sigma} \text{ or } Z = \frac{x}{\sigma}$$

In which :

Z = Standard Score

X = Raw Score

M = Mean of X Scores

σ = Standard Deviation of X Scores

The table of areas of normal probability curve are then referred to find out the proportion of area between the mean and the z value.

Though the total area under the N.P.C. is 1, but for convenience, the total area under the curve is taken to be 10,000 because of the greater ease with which fractional parts of the total area, may be then calculated.

The first column of the table, x/σ gives distance in tenths of σ measured off on the base line for the normal curve from the mean as origin. In the row, the x/σ distance are given to the second place of the decimal.

To find the number of cases in the normal distribution between the mean, and the ordinate erected at a distance of 1σ unit from the mean, we go down the x/σ column until 1.0 is reached and in the next column under .00 we take the entry opposite 1.0, namely 3413. This figure means that 3413 cases in 10,000; or 34.13 percent of the entire area of the curve lies between the mean and 1σ. Similarly, if we have to find the percentage of the distribution between the mean and $1.56\ \sigma$, say, we go down the x/σ column to 1.5, then across horizontally to the column headed by .06, and note the entry 44.06. This is the percentage of the total area that lies between the mean and 1.56σ.

Table 15.3.10.1 : Fractional parts of the total area (taken as 10,000) under the normal probability curve, corresponding to distances on the baseline between the mean and successive points laid off from the mean in units of standard deviation.

Example : Between the mean and a point $1.38\sigma \left(\frac{x}{\sigma}=1.38\right)$ are found 41.62% of the entire area under the curve.

$\frac{x}{\sigma}$	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	0000	0040	0080	0120	0160	0199	0239	0279	0319	0359
0.1	0398	0438	0478	0517	0557	0596	0636	0675	0714	0753
0.2	0793	0832	0871	0910	0948	0987	1026	1064	1103	1141
0.3	1179	1217	1255	1293	1331	1368	1406	1443	1480	1517
0.4	1554	1591	1628	1664	1700	1736	1772	1808	1844	1879
0.5	1915	1950	1985	2019	2054	2088	2123	2157	2190	2224
0.6	2257	2291	2324	2357	2389	2422	2454	2486	2517	2549
0.7	2580	2611	2642	2673	2704	2734	2764	2794	2823	2852
0.8	2881	2910	2939	2967	2995	3023	3051	3078	3106	3133
0.9	3159	3186	3212	3238	3264	3290	3315	3340	3365	3389
1.0	3413	3438	3461	3485	3508	3531	3554	3577	3599	3621
1.1	3643	3665	3686	3708	3729	2749	3770	3790	3810	3830
1.2	3849	3869	3888	3907	3925	3944	3962	3980	3997	4015
1.3	4032	4049	4066	4082	4099	4115	4131	4147	4162	4177
1.4	4192	4207	4222	4236	4251	4265	4279	4292	4306	4319
1.5	4332	4345	4357	4370	4383	4394	4406	4418	4429	4441
1.6	4452	4463	4474	4484	4495	4505	4515	4525	4535	4545
1.7	4554	4564	4573	4582	4591	4599	4608	4616	4625	4633
1.8	4641	4649	4656	4664	4671	4678	4686	4693	4699	4706
1.9	4713	4719	4726	4732	4738	4744	4750	4756	4761	4767
2.0	4772	4778	4783	4788	4793	4798	4803	4808	4812	4817
2.1	4821	4826	4830	4834	4838	4842	4846	4850	4854	4857
2.2	4861	4864	4868	4871	4875	4878	4881	4884	4887	4890
2.3	4893	4896	4898	4901	4904	4906	4909	4911	4913	4916
2.4	4918	4920	4922	4925	4927	4929	4931	4932	4934	4936
2.5	4938	4940	4941	4943	4945	4946	4948	4949	4951	4952
2.6	4953	4955	4956	4957	4959	4960	4961	4962	4963	4964
2.7	4965	4966	4967	4968	4969	4970	4971	4972	4973	4974
2.8	4974	4975	4976	4977	4977	4978	4979	4979	4980	4981
2.9	4981	4982	4982	4988	4984	4984	4985	4985	4986	4986

3.0	4986.5	4986.9	4987.4	4987.8	4988.2	4988.6	4988.9	4989.3	4989.7	4990.0
3.1	4990.3	4990.6	4991.0	4991.3	4991.6	4991.8	4992.1	4992.4	4992.6	4992.9
3.2	4993.129									
3.3	4995.166									
3.4	4996.631									
3.5	4997.674									
3.6	4998.409									
3.7	4998.922									
3.8	4999.277									
3.9	4999.519									
4.0	4999.683									
4.5	4999.966									
5.0	4999.997133									

We have so far considered only σ distances measured in the positive direction from the mean. For this we have taken into account only the right half of the normal curve. Since the curve is symmetrical about the mean, the entries in Table 15.3.10.1 apply to distances measured in the negative direction (to the left) as well as to those measured in the positive direction. If we have to find the percentage of the distribution between mean and -1.28σ, for instance, we take entry 3997 in the column .08, opposite 1.2 in the x/σ column. This entry means that 39.97 percent of the cases in the normal distribution fall between the mean and -1.28σ.

For practical purposes we take the curve to end at points -3σ and $+3\sigma$ distant from the mean as the normal curve does not actually meet the base line. Table of area under normal probability curve shows that 4986.5 cases lie between mean and ordinate at $+3\sigma$. Thus 99.73 percent of the entire distribution, would lie within the limits -3σ and $+3\sigma$. The rest 0.27 percent of the distribution beyond $\pm 3\sigma$ is considered too small or negligible except where N is very large.

15.3.10 Points to be kept in mind while consulting Table of Area under Normal Probability Curve

The following points are to be kept in mind to avoid errors, while consulting the N.P.C. Table.

1. Every given score or observation must be converted into standard measure i.e. Z score, by using the following formula :

$$Z = \frac{X - M}{\sigma}$$

2. The mean of the curve is always the reference point, and all the values of areas are given in terms of distances from mean which is zero
3. The area in terms of proportion can be converted into percentage, and
4. While consulting the table, absolute values of z should be taken. However, a negative value of Z shows that the scores and the area lie below the mean and this fact should be kept in mind while doing further calculation on the area. A positive value of z shows that the score lies above the mean i.e. right side.

15.3.11 Practical Problems related to Application of the Normal Probability Curve

a) **To determine the percentage of cases in a Normal Distribution within given limits or scores**

Example 1

Given a normal distribution of 500 scores with M = 40 and σ = 8, what percentage of cases lie between 36 and 48.

Solution

Z Score for raw score 36

$$Z = \frac{X - M}{\sigma}$$

$$Z = \frac{36 - 40}{8} = -\frac{4}{8}$$

or $Z = -0.5\sigma$

Z Score for 48

$$\frac{48 - 40}{8} = +\frac{8}{8}$$

or $Z = +1\sigma$

According to table of area under N.P.C (15.3.9.1) the total percentage of cases that lie between the Mean and $-.5\sigma$ is 19.15.

The percentage of cases between the Mean and $+1\sigma$ is 34.13.

Therefore total percentage of cases that fall between the scores 36 and 48 is 19.15 + 34.13 = 53.28.

b) **To determine the percentile rank of a student in his own group**

The percentile rank is defined as the percentage of scores below a given score.

Example 2

The raw score of a student of class X on an achievement test is 60. The mean of the whole class is 50 with standard deviation 5. Find the percentile rank of the student.

Solution

First we convert raw score 60 to Z score by using the formula.

$$Z = \frac{X - M}{\sigma}$$

$$Z = \frac{60 - 50}{5} = \frac{10}{5}$$

$Z = +2.00\,\sigma$

According to the table of area under N.P.C (15.3.9.1) the area of the curve that lie between M and $.+2\sigma$ is 47.72%.

The total percentage of cases below the score 60 is 50 + 47.22 = 97.72% or 98%

Thus, the percentile rank of a student who secured 60 marks in an achievement test in the class is 98.

c) **To determine the percentile value of a student whose percentile rank is known**

Example 3

In a class Rohit's percentile rank in the mathematics class is 75. The mean of the class in mathematics is 60 with standard deviation 10. Find out Rohit's marks in Mathematics achievement test.

Solution

According to definition of percentile rank the position of Rohit on the N.P.C. scale is 25% scores above the Mean.

According to the N.P.C Table the σ score of 25% cases from the Mean is $+.67\sigma$.

Thus by using the formula

$$Z = \frac{X - M}{\sigma}$$

$$+.67 = \frac{X - 60}{10}$$

$$\text{or } X - 60 = 10 \times .67$$

$$\text{or } X = 60 + 6.7$$

$$\text{or } X = 66.7 \text{ (Say 67)}$$

Rohit's marks in mathematics are 67.

d) **Dividing a group into sub-groups according to the level of ability**

Example 4

Given a group of 500 college students who have been administered a general mental ability test. The teacher wishes to classify the group in five categories and assign then grades A, B, C, D, E according to ability. Assuming that general mental ability is normally distributed in the population; calculate the number of students that can be placed in groups A, B, C, D and E.

Solution

We know that total area of the Normal Curve extends from -3σ to $+3\ \sigma$ that is over a range of 6σ.

Dividing this range by 5, we get the σ distance of each category = $6\sigma/5 = 1.2\sigma$. Thus, each category is spread over a distance of 1.2σ. The category C will lie in the middle. Half of its area will be below the mean, and the other half above the mean.

The σ distance of each category is shown in the figure.

According to N.P.C table the total percentage of cases from mean to $.6\sigma$ is 22.57.

The total cases in between $-.6\sigma$ to $+.6\sigma$ is 22.57 + 22.57 = 45.14%.

Hence, in category C, the total percentage of students is = 45.14.

Similarly according to N.P.C. Table the total percentage of cases from Mean to 1.8σ is 46.41.

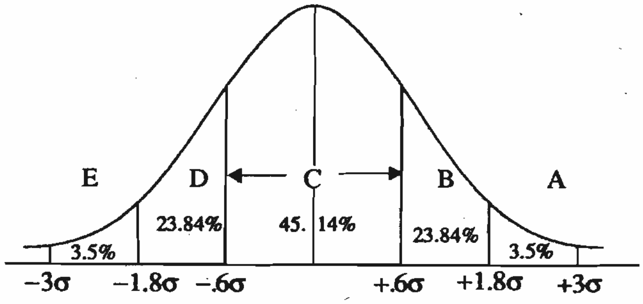

Fig. 15.9

The total percentage of cases in category B is $46.41 - 22.57 = 23.84\%$.

In category A the total percentage of the cases will be $50 - 46.41 = 3.59\%$.

Similarly in category D and E the total percentages of the students will be 23.84% and 3.59% respectively. Thus :

In category A the total percentage of students is 3.59%

In category B the total percentage of students is 23.84%

In category C the total percentage of students is 45.14%

In category D the total percentage of students is 23.84%

In category E the total percentage of students is 3.59%

Exact numbers out of 500 can now be worked out.

15.4 LET US SUM UP

The normal distribution is a very important concept in the behavioural sciences because many variables used in behavioural research are assumed to be normally distributed.

Normal curve is very helpful in educational evaluation and measurement. It provides relative positioning of the individual in a group. It can also be used as a scale of measurement in behavioural sciences.

The normal distribution is a significant tool in the hands of teacher, through which he can decide the nature of the distribution of the scores obtained on the basis of measured variable. He can judge the difficulty level of the test items in the question paper and finally he may know about his class, whether it is homogeneous to the ability measured or it is heterogeneous one.

15.5 UNIT-END EXERCISES

1. Take some frequency distribution and prepare the frequency polygons. Study the normalcy in the distribution. If you obtain non-normal distribution, determine the type of skewness and kurtosis. Also list down the probable causes associated to the non-normal distribution.

15.6 POINTS FOR DISCUSSION

1. Determine which variables related to cognitive and affective domain of behaviour are normally distributed.

2. As a teacher, what precautions are to be taken while preparing a question paper or test paper ?

15.7 ANSWERS TO CHECK YOUR PROGRESS

1. i) Normal Probability Curve is the bell shaped curve obtained for a distribution having maximum frequency near the central value of distribution and the frequency gradually tapering off symmetrically on both the sides.

   ii) The Normal Curve is symmetrical about the ordinate at the central point of the curve.

   - It is unimodal, the mode is always at the central point of the curve.
   - It is asymptotic to the x-axis.
   - The points of influx occur at $\pm 1\sigma$.
   - The area of the curve between the points of influxation is fixed.

   iii) A frequency distribution is approximating the normal distribution if

   - it has maximum frequency at the central value of the distribution;

- the frequency goes on decreasing, as we move away from the central value of distribution in a symmetric way in both the directions;
- between $\pm 1\sigma$ there are approximately two - third of the cases; and
- almost all the cases lie between $\pm 3\sigma$.

iv) a) Between -1σ and $+1\sigma$, there are 68.26% of the frequencies;

b) Between -2σ and $+2\sigma$, there are 95.44% of the frequencies; and

c) Between -3σ and $+3\sigma$, there are 99.73% of the frequencies;

v) The two ends of the normal probability curve are considered closed at the points $\pm 3\sigma$, as almost all the cases (99.73% of the cases, to be exact) lie between these two points and there is a rare probability of a case going beyond these two limits.

2. i) a) A distribution is said to be skewed, if the point of centre of gravity is located on one side of the distribution i.e. away from the centre of the scale of measurement.

b) Kurtosis refers to the divergence in the height of the curve or the peakedness of the curve.

c) A distribution is said to be negatively skewed if the scores are concentrated at the higher end of the measurement scale and it is said to be positively skewed if the scores are concentrated at the lower end of the measurement scale.

d) A distribution of flatter peak than the normal one is known as platy - kurtosis distribution.

e) A distribution which is more peaked than the normal one is known as lepto-Kurtosis distribution.

ii) In case of normal distribution the value of Kurtosis is 0.263.

iii) If the distribution of scores obtained by a school teacher is not normal, he/she will try to find out the reasons of skewness and kurtosis of the distribution. One of the reasons may be that the group of individuals is different from the normal one, or it may be due to the nature of the trait itself. Teacher should know that ultimately the goal of education is to have the distribution of scores of individuals as negatively skewed.

15.8 SUGGESTED READINGS

Aggarwal, Y.P. (1990), *'Statistical Methods – Concepts, Applications and Computation'*, Sterling Publishers Pvt. Ltd., New Delhi.

Ferguson, G.A. (1974), *'Statistical Analysis in Psychology and Education'*, McGraw Hill B.K. Co., New York.

Garrett, H.E & Woodworth, R.S.(1969), *'Statistics in Psychology and Education'*. Vakils, Feffer & Simons Pvt. Ltd., Bombay.

Guilford, J.P. & Benjamin, F. (1973), *'Fundamental Statistics in Psychology and Education'*, McGraw Hill B.K. Co., New York.

Srivastava, A.B.L. & Sharma, K.K. (1974), *'Elementary Statistics in Psychology and Education'*, Sterling Publishers Pvt. Ltd, New Delhi.