Normalization

1. **Purpose:** If test is conducted in batches with different set of questions, there is possibility that the difficulty level may differ and in such an event to have scores of both batches comparable, process Normalization is adopted.

2. **Process:** Mean and Standard Deviation is ascertained for the Base as well as Targeted Batch. Formula is applied using these figures to the Scores of Targeted Batch and Normalized score is obtained.

   The base factors for the calculation are:

   A) Proportion of Deviation
   B) Difference between Target Value and Average Value
   C) Average Value

   and the formula used to get Normalized Score is A x B + C.

The elements comprising the above factors are modified to achieve precise results based on of data (Scores of candidates in different Batches) resulting in different methods. These methods are explained in Annexure “A”.

3. **Assumptions / Pre-requisite:** Basic assumption in this process is that scores in both Base Batch and Targeted Batch have Normal Distribution.

   The main disadvantage of Normalized **scores** is that they always assume a normal distribution. But if this assumption is not met, the **scores** cannot be interpreted as a standard proportion of the distribution from which they were calculated.

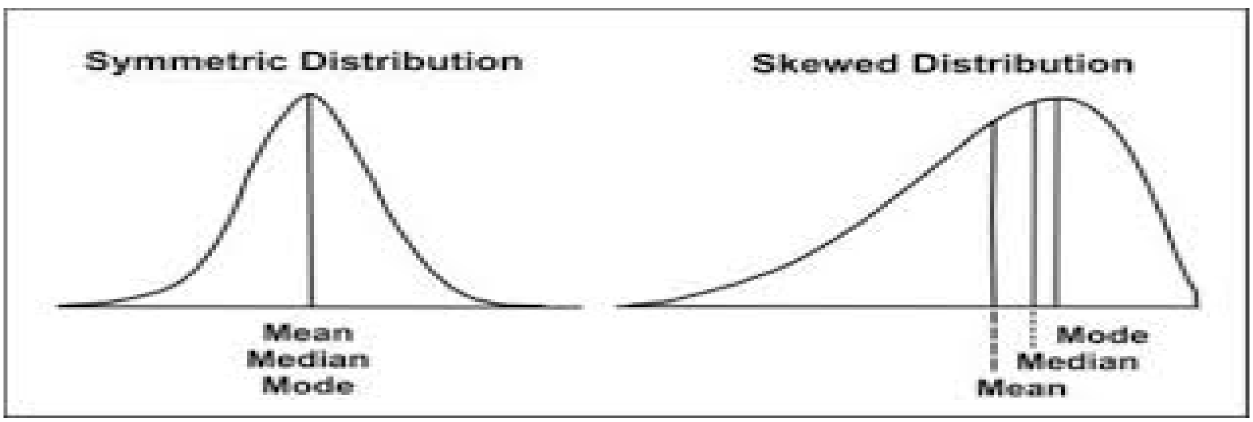
It is said that you need to take at least 30 samples, to be "sure" that you have an exact enough mean and deviation estimates.

It is interesting to note here that, even if a sample is taken from one batch, the size needs to be adequate enough, and then only it can represent approximate distribution of that batch. (Ref : Central Limit Theorem)

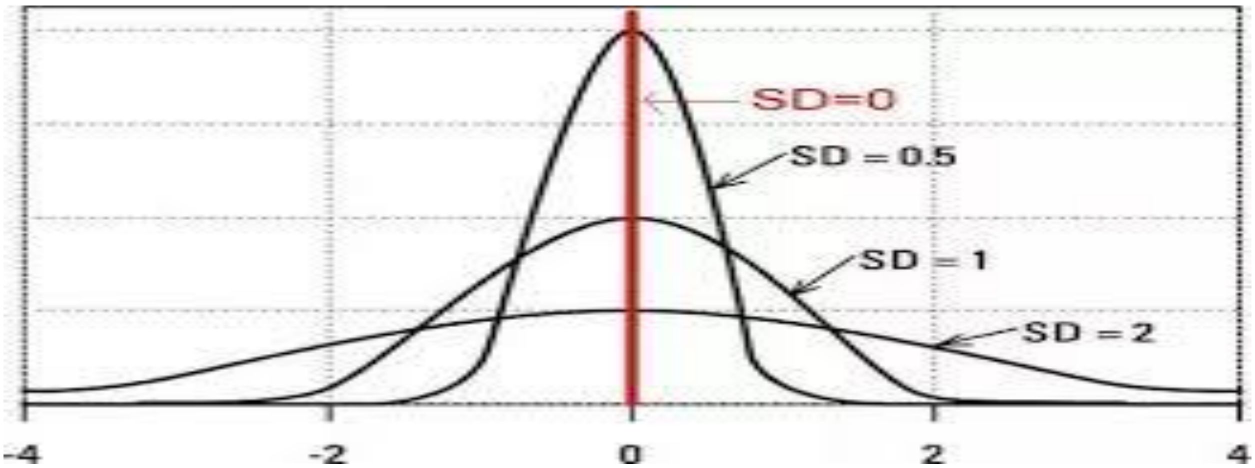
The choice of n = 30 for a boundary between small and large samples is a rule of thumb, only. There is a large number of books that quote (around) this value, for example, Hogg and Tanis' *Probability and Statistical Inference* (7e) says "greater than 25 or 30".

A. Considering above said **Assumptions / Pre-requisite** Normalization can not be done under following circumstance and the score needs to be left as it is for ranking purpose.
   - In case the size of Base Batch or Target Batch is less than 30
   - In case the test Question Papers are not comparable (i.e. with different subject matter content, different pattern / level)

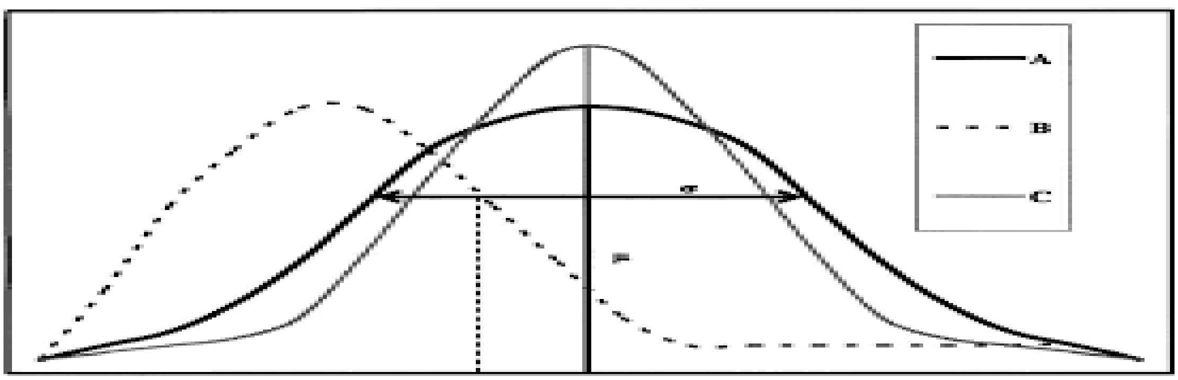
B. The distribution of scores is normal. It may be skewed towards right or left to some extent depending upon the overall performance of candidates.



C. Even if Average Score of 2 Batches is same the distribution of Scores may be different. This will reflect the comparative difficulty level of questions administered for different Batches.



D. In the following diagram the B (data plotted in dotted line) represents more difficult Questions used in the Batch as compared to A and C



E. Annexure “A” enumerates different methods for normalizing scores using different formulas. There is no hard and fast rule for the purpose of selecting the method to be applied, however considering the formulas used, inferences could be drawn as to the circumstances in which they are applied.

4. Conclusion: Considering what has been stated above and also various methods mentioned in annexure “A”, In our opinion :

a) Normalization cannot be done under following circumstance and the score needs to be left as it is for ranking purpose.
   - In case the size of Base Batch or Target Batch is less than 30.
   - In case the test Question Papers are not comparable (i.e. with different subject matter content, different pattern / level)

b) As regards Method B and C :
   - There is a factor “Top 0.1% candidates. If the absolute value of the same is expected to be at least 30, then the batch size needs to be

minimum 30,000. In view of this these methods are not recommended where batch size is less than 30,000.

- Where the size of batches does not differ significantly, concept of Base Batch can be adopted and therefore Method B will be suitable.
- In other case Method C will be suitable

c) Method A or D can be used in all other cases however Method A may be preferred where the examination is related with specific domain knowledge whereas Method D would be suitable for General Knowledge. It is desirable that the size of Base Batch and Target Batch is not less than 300.

Annexure A

Method A

- Score Normalization using Mean and Standard Deviation of Base / Standard and Target Batch

$$Xn = (S_2/S_1)*(X-X_{av}) + Y_{av}$$

Where:
Suffix 1 and suffix 2 represent two sets of marks.
S represent standard deviation.
X and X_{av} represent raw score and average score for set 1.
Y and Y_{av} represent raw score and average score for set 2.
And Xn = Normalized score.
Supposing set 1 is to be scaled against set 2 (which is declared as standard)

In this method there are following 3 factors:

A) Ratio of SD of Base / Standard Batch to SD of Targeted Batch
B) Difference of Score of Candidates and Average Score of the Target Batch
C) Average Score of Base / Standard Batch
Normalized Score = A x B + C

Batch with maximum average with minimum 70% of the overall average attendance is considered as the Base / Standard Batch.

Method B

$$\widehat{M}_{ij} = \frac{\overline{M}_t^g - M_q^g}{\overline{M}_{ti} - M_{iq}} x\left(M_{ij} - M_{iq}\right) + M_q^{gm}$$

Where,

$\widehat{M}_{ij} = Normalized\ marks\ of\ j^{th}\ candidate\ in\ i^{th} shift\ (up\ to\ 5\ decimal\ places)$

$\overline{M}_t^g = Average\ marks\ of\ top\ 0.1\%\ candidates\ considering\ all\ shifts$

$M_q^g = Sum\ of\ mean\ and\ Standard\ Deviation\ marks\ of\ candidates$ $in\ the\ exam\ considering\ all\ batches$

$\overline{M}_{ti} = Average\ marks\ of\ top\ 0.1\%\ candidates\ in\ i^{th} shift$

$M_{iq} = Sum\ of\ mean\ and\ Standard\ Deviation\ of\ i^{th} shift$

$M_{ij} = Raw\ /\ Scaled\ Marks\ obtained\ by\ j^{th} candidate\ in\ i^{th} shift$

$M_q^{gm} = Sum\ of\ mean\ marks\ of\ candidates\ (in\ the\ shift\ having\ max.\ \ mean)$ $and\ Standard\ Deviation\ of\ candidates\ considering\ all\ batches$

---

1. In this case additional elements like Average and Standard Deviation of top 0.1% of overall candidates as well as that of targeted batch are brought in the picture.
2. By using Proportion of difference (Average score of Top 0.1% candidates minus Average+ SD of all candidates' score) for all shifts to targeted shift the ***purpose to normalize the data more precisely is achieved if there is significant variation in marks scored by top 0.1% candidates in different batches.***
3. Concept of Base / Standard and Target Batch is maintained.
4. Since ratio as indicated in 2 is used as one of the factor for the purpose of normalization of candidate's score, instead of difference between score of the candidate and average score of the Base Batch, difference between score of the candidate and average + SD of score of the Base Batch is taken.
5. Having taken proportionate difference as stated above Average + SD of score for all batches is added to it. Here SD is also added because while calculating proportionate difference SD is also deducted from candidate's score.

Method C

$$\widehat{M}_{ij} = \frac{\overline{M}_t^g - M_q^g}{\overline{M}_{ti} - M_{iq}} x\left(M_{ij} - M_{iq}\right) + M_q^g$$

Where,

$\widehat{M}_{ij} = Normalized\ marks\ of\ j^{th}\ candidate\ in\ i^{th} shift\ (up\ to\ 5\ decimal\ places)$

$\overline{M}_t^g = Average\ marks\ of\ top\ 0.1\%\ candidates\ considering\ all\ shifts$

$M_q^g = Sum\ of\ mean\ and\ Standard\ Deviation\ marks\ of\ candidates$ $in\ the\ exam\ considering\ all\ batches$

$\overline{M}_{ti} = Average\ marks\ of\ top\ 0.1\%\ candidates\ in\ i^{th} shift$

$M_{iq} = Sum\ of\ mean\ and\ Standard\ Deviation\ of\ i^{th} shift$

$M_{ij} = Raw\ /\ Scaled\ Marks\ obtained\ by\ j^{th} candidate\ in\ i^{th} shift$

This method is similar to Method B except change in "Factor C" i.e. instead of "Sum of mean marks of candidates (in the shift having max. mean) and Standard Deviation of candidates considering all batches" , "Sum of mean and Standard Deviation marks of candidates in the exam considering all batches" is considered.

Therefore, this method is appropriate where all Batches are equally important or unique and no Batch can be taken as a Base / Standard Batch.

Method D - Using Equi-Percentile

$$\text{Percentile Rank of Candidate} = \frac{\text{Total Candidates in Shift - Rank of the candidate in that shift}}{\text{(Total candidates in the shift -1)}} \times 100$$

In this method Batch-wise Percentile Rank of Candidate is calculated as per the above formula and thereafter All data is merged for further process of short-listing.

Once the percentiles are calculated, the batch having the most number of candidates appeared is considered as Base Batch.

If Equated Score is required to be displayed, instead of Percentile Rank, before merging data of all batches the same is calculated using the following formula. However this does change Merit Order as prepared based on Percentile Rank of Candidate.

$$Y = Y1 + \frac{Y2 - Y1}{(X2 - X1)} x(X - X1)$$

Where:

Y = Equated Score rounded up to 2 decimal places

Y1 = Marks corresponding to immediate lower percentile form Batch II

Y2 = Marks corresponding to immediate upper percentile form Batch II

X1 = Immediate lower percentile form Batch II

X2 = Immediate upper percentile form Batch II

X = Percentile of the Candidate of the respective Batch

=======