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Common Merit List Generation Method for Multi Shift Exam using Difficulty Index Value of Question Paper

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Abstract: ***The competitive examinations conducted in multiple shifts have different question papers for different shifts. The assigned difficulty index of the entire question papers are kept same for the entire shift, however the calculated difficulty index may vary. The major challenge faced in the conduction of the multiple shift examination is the generation of the common merit list. This research paper concentrates on the study of various merit list generation techniques used for multi shift examinations. It also proposes a new merit list generation method taking in to consideration the difficulty index of the question paper. This paper also compares various merit list generation techniques such as actual score method, normalized score method, percentile score method and the proposed difficulty index based score method. The merit list generated by percentile score method gives equal number of selection from each shift and does not consider the difficulty index of the question paper. Whereas in normalization method, the score is normalized by considering the mean, standard deviation of the score of each shift and of all shifts. This method also equalises the selection count. However the proposed techniques take in to account the difficulty index of the question paper as well, which may vary the selection count in each shift. This assures that the deserving and the eligible candidate does not get affected due to the difficulty level variation of question paper.***

Keyword: ***Difficulty index, Discriminating index, Normalized score, Percentile score, Multiplication factor.***

I. INTRODUCTION

The conduction of examination is a very crucial job in today's online scenario. Most of the Govt, public sector organisation recruits employees, renowned education institutes also gives admission to the deserving candidates by conducting examination. Every year lakhs of students and individuals appear in the competitive examinations. The purpose of such examinations is to recruit suitable candidates for the job in the public sector or to give admission to the students in a reputed institution. These exams are either OMR (Optical Mark Reader) or CBT (Computer Based Test) based [17].

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Computer based exams are conducted in multiple sessions in which lakhs of candidates appear for the exam. The exam conducted in multiple sessions requires different question paper of same difficulty level for each session. Since different question paper is used in different sessions of the same exam, the difficulty level of the session may vary. It is necessary to bring the effect of varying difficulty level of question paper in all the sessions to the same level in order to generate the common merit list of the examination. Hence there is a need to bring the marks of the candidate appearing in different sessions to the same level to neutralize the effect of different difficulty level of the question paper. Normalization or percentile score based methods are generally adopted by the examination conducting bodies [17].

The difficulty index determines the validity of test questions; it is a measure of proportion of students who answer a particular question correctly in test. The higher index value indicates that a greater proportion of students answered that question correctly. The difficulty index is computed as the number of students who answered a question correctly divided by the total number of students who answered the question (s). The discrimination index is another way to evaluate the validity of the tests. It indicates how well individual question sorts students who have mastered the material from students who have not.

II. LITERATURE REVIEW

The study [1] sheds light on the item analysis of MCQ used in formative assessment by assessing 112, 1st year MBBS students on a given set of 45 MCQ answers ,further calculating the discriminative and difficulty index .The only limitation being the smaller no of items and a single group on which the entire study was focussed, the research concluded that the items having moderate difficulty had good to excellent discriminating index, on the other hand too easy and too hard items had poorer index, although no negative discriminating index suggested good framing of MCQs.

The research study [2] revolves around analysing 20 MCQs, regarding vowel sounds of English having asked the first-year major English students. The good discriminating index indicated the good quality of MCQs selected, the researchers recommend carrying out such research more often to identify item of acceptable discriminative index saved for further examinations.

The main aim of this study [3] is to find out item difficulty along with the power of discrimination of MCQ test items. Random sampling involving 200 students and teachers constituting of both genders were taken into account the difficulty index and discrimination index. It can be done for other subjects as well to create a better item bank for student community as it helps structure a solid item bank.

The item analysis was done by two methods based on difficulty index and discrimination index in the research paper [4]. Data was analyzed for standard error of difference between two proportions by Microsoft Excel. Z test for two proportions showed no significant difference in the difficulty index with new and conventional method. The study shows that there is no difference in difficulty index by both methods.

The research paper [5] takes into consideration the cognitive skills of the test takers in an open learning context .The study comprises of 905 multiple questions and 20 learners. Contrary to the earlier studies this research states that questions measuring low level cognitive skills had better discriminative index.

The main objective of the research paper [6] was to find out the difficulty index and the discrimination index for each item in a physiology test paper conducted, comprising of 20 questions and 250 physiotherapy students took the test. The study concluded that difficulty index and discriminating index are of utmost importance and an item with known and acceptable difficulty level and discriminating power should be preserved for further examinations.

The study [7] shows that the relationship between the item difficulty index and discrimination index for each test item was determined by Pearson correlation analysis using SPSS 11.5. The test items demonstrating excellent discrimination tend to be in the moderately difficult range. The result of the study concludes that many more such assessments on the discrimination power should be made to identify the areas of potential weakness to improve the standards of assessment

The sole crux of the study [8] is the assessment of assessments. Total of 120 students took the MCQ consisting of 40 questions .The results further reemphasized earlier results. Moderately difficulty items had the maximal discriminative ability. Items with higher difficulty index had poor discriminating index. It encourages a proper assessment strategy to be taken into account while modelling a MCQ.

The author [9] discuss about various normalization schemes used in India when an examination involving multiple choice questions is conducted across various sessions. The paper describes how the percentile-based normalization scheme outperforms all the other schemes and argued that the standardization step should use percentile score.

Percentile ranks [13] and I3 indicator were introduced by Bornmann, Leydesdorff, Mutz and Opthof. These are based on the concept of percentiles for discrete data. The work shows that if the notion of relative congruous indicators is carefully defined then percentile rank scores are congruous indicators of relative performance.

III. METHODOLOGY

Most of the competitive exams are conducted in multiple shifts in which lakhs of candidates are involved. In multiple shift examination, a separate paper is required for each shift. Even though the assigned difficulty level of all the papers of the examination conducted in multiple shifts is kept at the same level, the calculated difficulty level of the question paper of different shifts may vary. Score equalization process is followed so as to bring the difficulty level of the multiple shift exams to the same level so that it appears as a single shift exam.

Item analysis is the statistical analysis of individual test questions. Two statistical methods used in item analysis are the difficulty index and the discrimination index. The difficulty index determines the proportion of students who answered the item correctly. The Discrimination Index differentiates between candidates who have mastered the subject and those who have not.

A. Objective of the Research

Study of the existing methods adopted by the examination conducting bodies to generate merit list of the candidates appeared in different shifts of the same examination.

To propose a new method to generate merit list of the candidates appeared in different shifts of the same examination by considering the difficulty level of the question paper.

1. Comparison of existing methods with the proposed method.

B. Existing Methods

- *Normalized Score Based Merit*

Normalization is adopted to normalize the marks of candidates of different shifts by putting them on a common scale [9]. These normalized marks or scores are then used to rank the candidates for admission or job. Different normalization methods will give different rankings of the candidates. The various methods are z-score method, w-score method, g-score method. These methods transform the score using mean and standard deviation.

The candidate's scores and their shift details are stored and normalized to prepare the final merit list. In the normalization process, the mean and standard deviation of each shift, 0.1 percent of the average of each shift, are calculated and stored. The normalized score of yth candidate in xth shift is Nxy [10] [11] [17] is given by:

$$Nxy=(A-B)*(Cxy-D)/(E-D)+B \quad (1)$$

Where Cxy is the actual marks obtained by the yth candidate in xth session, A is the average marks of the top 0.1% of the candidates considering all sessions, B is the sum of mean and standard deviation marks of the candidates in the paper considering all sessions, E is the average marks of the top 0.1% of the candidates in the xth session [12], D is the sum of mean and standard deviation marks of xth sessions.

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- *Percentile Score Based Merit*

The percentile rank of a score is the percentage of scores in its frequency distribution that are equal to or lower than it [13] [14]. According to Ary and Jacobs [15] , " A percentile rank gives us the relative rank of a score with in a distribution, based on a scale of 100". While Garrett says, "The percentile rank of an individual is the position on a scale of 100 to which the subject's score entitle him." The Kth percentile of a given score in any distribution is the point on the score scale below which 'K' percent of the scores fall. The percentile rank [15] of a given point on a score scale is the percentage of measures in the whole distribution which are below that given points. In order to calculate the values of percentile, one needs to locate the points on the scale of measurement up to which the given percent of cases lie.

- *Proposed Difficulty Level Score Based Merit*

The score of the candidate who appeared in the multiple shift exams are stored. The candidate's responses are recorded as 0 or 1 for each question in the question paper. Response value zero indicates that the candidate has chosen the wrong answer for that question and response value one indicates that the candidate has chosen the correct answer for that question. New proposed merit list creation technique and existing technique is applied on shift wise candidate score. The process flow of the work is given below: -

1. Study of existing merit list generation methods i.e. actual score method, normalized score method, percentile score method.
2. Data sheet of exam conducted in multiple shifts are used to prepare the merit list based on actual score method, normalized score method and percentile score method.
3. New method based on the difficulty index is applied in the data set to generate the merit list. The following steps are followed to generate the merit list based on proposed method:-

i. Candidate's score and their responses to each question of the question paper are registered in the form 0 and 1 during the exam.

ii. Prepare the shift wise data sheet for each question of the question paper with candidate responses. Suppose if the question paper has 100 questions in the question paper, for each 100 question find the following: -

a. Correct answer count: Number of candidates who answered correctly.
b. Unanswered count: No of candidates not attempted the question.
c. Answered candidate count: No of candidates attempted the question.
d. Find difficulty index [16] of each question of the question paper using equation (1):
e. Difficulty index (Dq) = Correct answer count/ Answered candidate count..... (1)

iii. The difficulty level of question paper of particular shift is calculated by finding the average of difficulty index (Ds) of all questions of the question paper of that particular shift.

iv. Sort the score sheet of each shift in descending order. Divide each shift datasheet in to two equal parts high scored candidate in one part and low scored candidate in other part. Find all parameters mentioned in Step III and Step IV for each of the high score and low score part for each shift.

v. Find Discriminating index [16] of each question of question paper as given below:

$$\text{Discriminating index} = Hc - Lc)/t$$

Where Hc is answered candidate count in high scored candidate part, Lc is answered candidate count in low scored candidate part and t is total number of candidates in each part.

vi. Determine average Discriminating index of a question paper of each shift.

vii. Find average of difficulty index of all shift (Da).

viii. Calculate Multiplication factor of each shift (Msi) as given below:

$$Msi = Ds/Da$$

ix. Difficulty level based score is calculated by multiplying the candidate scores of each shift with multiplication factor (Msi) of respective shift.

x. The above difficulty level based of all shifts are merged in to single sheet, sort the merged sheet in descending order.

xi. Prepare the merit list by picking the number of candidates equal to the number of posts/seats.

xii. The above prepared merit list is based on the difficulty level score-based merit.

xiii. Compare the merit list based on proposed method with three existing methods

IV. EXPERIMENTAL RESULT

The data set of 133934 candidates appeared in 11 shifts are used and applied all four methods to generate merit list. Prepare the shift wise data sheet; each data sheet includes the responses of candidates in the form of 0 or 1 for each question in the question paper. The question paper is of 100 questions in all. For each 100 question the correct answer count, unanswered count and Answered candidate counts are found. The Correct answer count, unanswered count, Answered candidate counts and difficulty level with sample data of 6 questions answered by 10 candidates are shown in Table 1.

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Table 1. Difficulty level and Sample data of Set10

Roll number	Shift Set	Qu 1	Qu 2	Qu 3	Qu 4	Qu 5	Qu 6
52001	Set10	1	1	1	1	0	1
52002	Set10	1	0	1	1	1	1
52003	Set10	1	0	1	1	0	1
52004	Set10	0	0	1	1	1	1
52005	Set10	1	1	1	1	1	1
52006	Set10	1	1	1	1	0	1
52007	Set10	1	1	0	1	1	1
52008	Set10	1	0	1	1	0	1
52009	Set10	1	1	0	1	0	1
52010	Set10	1	1	0	0	1	1
Correctly answered count		2728	3121	3277	2432	1413	2429
Unanswered count		41	43	40	68	69	76
Answered candidate count		5913	5911	5914	5886	5885	5878
Difficulty	0.486162152	0.461356	0.527999	0.554109	0.413184	0.240102	0.413236

The score sheet of each shift is sorted and divided in to two equal parts, high scored candidate in one part and low scored candidate in other part. All parameters mentioned above for each of the high score and low score part for each shift are found. Discriminating index [16] of each question of question paper, average Discriminating index of a question paper of each shift and average of difficulty index of all shift (Da) are computed as shown in Table 2.

Table 2. Discriminating index and Difficulty level

Question id	Correctly answered count of Lower rank candidates (LC)	Unanswered count of Lower rank candidates	Answered candidate count of Lower rank candidates	Correctly answered count of Higher rank candidates (HC)	Unanswered count of Higher rank candidates	Answered candidate count of Higher rank candidates	Discriminating index (HC-LC)/t	Difficulty index
Qu 1	1550	289	5665	2728	41	5913	0.197883	0.369558
Qu 2	2068	300	5654	3121	43	5911	0.176886	0.448759
Qu 3	1517	302	5652	3277	40	5914	0.295649	0.414562
Qu 4	1486	332	5622	2432	68	5886	0.158911	0.340518
Qu 5	942	328	5626	1413	69	5885	0.07912	0.204622
Qu 6	950	332	5622	2429	76	5878	0.248446	0.293877
-	--	-	-	-	-	-	-	-
Qu 97	1911	105	5849	3476	18	5936	0.262893	0.457184
Qu 98	1323	144	5810	2370	84	5870	0.175878	0.316236
						Average	**0.18968**	**Ds= 0.395357**

A. The Multiplication factor of each shift (Msi) is computed and shown in Table 3. The Difficulty level based score is calculated by multiplying the candidate scores of each shift with multiplication factor (Msi) of respective shift. The above difficulty level based scores of all shifts are merged in to single sheet; sort the merged sheet in descending order.

Table 3. Shift wise multiplication factor and Multiplication factor based on higher rank candidate

Shift Set	Total candidate	Difficulty index based score candidate count in merit list (D)	Actual score based candidate count in merit list (A)	Normalised score based candidate count in merit list (N)	Percentile score based candidate count in merit list (P)	Difference of Difficulty and Actual score based count (D-A)	Difference of Difficulty and Normalized score based count (D-N)	Difference of Difficulty and Percentile score based count (D-P)
Set10	11906	78	108	134	119	-30	-56	-41
Set11	12037	175	167	106	120	8	69	55
Set1	12425	135	215	164	124	-80	-29	11
Set2	12261	96	83	83	122	13	13	-26
Set3	12634	172	41	101	126	131	71	46
Set4	12707	75	58	99	127	17	-24	-52
Set5	11572	73	54	94	116	19	-21	-43

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Set7	12005	101	128	128	120	-27	-27	-19
Set9	11367	71	181	129	114	-110	-58	-43
Set6	12414	126	97	126	124	29	0	2
Set8	12606	236	206	174	126	30	62	110
Grand Total	**133934**	**1338**	**1338**	**1338**	**1338**	**0**	**0**	**0**
Min Range		**71**	**41**	**83**	**114**	**-110**	**-58**	**-52**
Max Range		**236**	**215**	**174**	**127**	**131**	**71**	**110**

B. The difficulty level score based merit list is prepared by picking the number of candidates equal to the number of posts/seats assumed as 1% of the total number of candidates appeared. Similarly, the normalized score based and actual score based merit list is prepared. All four methods based merit lists are compared and Difference between candidate count of each method and its percentage differences are shown in Table 4. and Table 5.

The max and min percentage variation of difference of difficulty level score based count and actual score based count is 1.04+.97=2 , difference of difficulty level score based count and normalized score based count is 0.57+0.51=1.08 and difference of difficulty level score based count and percentile score based count is 0.87+0.41=1.28 . It indicates that difference in difficulty level score based count and normalized score based count is minimum as shown in Table 5.

Table 4. Comparison of all four methods and difference in candidate count

S. No	Shift	Candidate count	Question count	Discriminating index	Difficulty index (Ds)	Shift wise multiplication factor	Multiplication factor based on higher rank candidate (Msi=Ds/Da)
1	Set10	11906	98	0.19	0.4	0.997755	1
2	Set11	12037	94	0.19	0.39	1.007056	1
3	Set1	12425	98	0.2	0.41	0.962695	0.96
4	Set2	12261	98	0.17	0.39	1.017965	1.03
5	Set3	12634	94	0.17	0.36	1.087864	1.1
6	Set4	12707	97	0.17	0.39	1.014229	1.02
7	Set5	11572	100	0.17	0.39	1.022071	1.03
8	Set7	12005	98	0.18	0.4	0.982604	0.99
9	Set9	11367	94	0.19	0.41	0.957382	0.96
10	Set6	12414	97	0.19	0.39	0.999203	1
11	Set8	12606	100	0.19	0.39	1.016353	1.01
Total		**133934**	**Average**	**0.18**	**Da= 0.39**	**1.005925**	**1.01**

Table 5. Comparison of all four methods and difference in percentage of candidate count

Shift Set	Total candidate	% Difficulty score based count (%D)	%Actual score based count (%A)	% Normalized score based count (%N)	% Percentile score based count (%P)	Difference of % (D-A)	Difference of % (D-N)	Difference % (D-P)
Set10	11906	0.66	0.91	1.13	1	-0.25	-0.47	-0.34
Set19	12037	1.45	1.39	0.88	1	0.07	0.57	0.46
Set21	12425	1.09	1.73	1.32	1	-0.64	-0.23	0.09
Set22	12261	0.78	0.68	0.68	1	0.11	0.11	-0.21
Set23	12634	1.36	0.32	0.8	1	1.04	0.56	0.36
Set24	12707	0.59	0.46	0.78	1	0.13	-0.19	-0.41
Set25	11572	0.63	0.47	0.81	1	0.16	-0.18	-0.37
Set26	12005	0.84	1.07	1.07	1	-0.22	-0.22	-0.16
Set34	11367	0.62	1.59	1.13	1	-0.97	-0.51	-0.38
Set6	12414	1.01	0.78	1.01	1	0.23	0	0.02
Set8	12606	1.87	1.63	1.38	1	0.24	0.49	0.87
Average	**133934**	**0.99**	**1**	**1**	**1**	**-0.01**	**-0.01**	**-0.01**
Min Range		**0.59**	**0.32**	**0.68**	**1**	**-0.97**	**-0.51**	**-0.41**
Max Range		**1.87**	**1.73**	**1.38**	**1**	**1.04**	**0.57**	**0.87**

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xiv.The Figure 1 shows the graph of selected candidate count of all four methods. The graph shows that the candidate counts in all sets are almost equal in percentile score method. The actual score method shows more variation in candidate count. The normalized score method addresses the mean and standard deviation of the score and difficulty score method addresses the difficulty level of the question paper. The selection count in both methods shows almost similar graph.

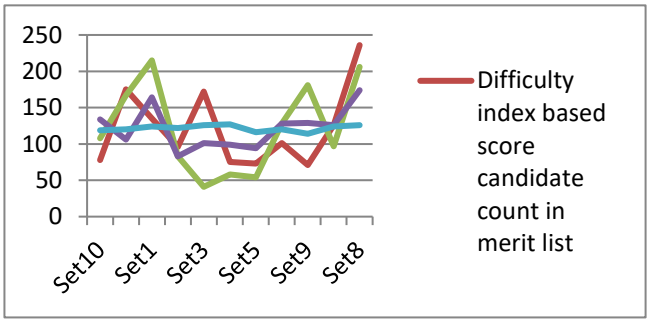

Fig.1. Candidate count in common merit list generated by all four methods

V. CONCLUSION

The proposed method is tested on the exam of 133934 candidates conducted in 11 shifts. The selection count in each session based on the difficulty level based score, actual score based method, normalized score based method and percentile score based method are compared. The percentile method equalizes the selection count across all sessions. This method keeps the percentage of selection from each session same however does not address the difficulty level of the question paper. The normalization method also tries to equalize the count of selections across all sessions, which depends on the variation in average score and standard deviation in scores of the candidate of each shift.

The selection count of proposed method and percentile score based method varies immensely, as percentile method concentrates on equalizing the selection count without considering the effect of difficulty level of the question paper in each shift. The proposed method addresses the difficulty level of the question paper and is remarkably similar to the normalized score based method. The proposed method gives better insight on student's calibre by addressing the difficulty index of the question paper. It can be further improved by including the effect of discriminating index of each question in the candidate score to select deserving candidate for the job or admission.

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