Comparison of Three Algorithms for Analyzing Questionnaire-Type Needs Assessment Data to Establish Need Priorities

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Needs assessment has been recognized as an important part of curriculum planning for many years. Commonly, need assessments are conducted to identify discrepancies between an existing state of affairs and a desired or ideal state (Kaufman, 1977; Witkin, 1977). Kaufman (1976) and Kaufman and English (1979) define needs assessment as a method for identifying gaps between present and desired outcomes. They present the overall process as one in which three major steps are taken:

1. Identifying of all the relevant gaps,
2. Prioritizing the gaps that are identified, and
3. Selecting the highest priority gaps for closure.

Under this model there are different ways to gather data, and different data collection techniques imply different analysis approaches. Needs assessment data collected via a nominal group technique (e.g., see Harrison, Peitri & Moore, 1983; or Scott & Deadrick, 1982) would be generated and analyzed differently from data collected via a large-scale survey in which ratings of desired states are compared to an assessment of the existing state of affairs (e.g., see Lane, Crofton, & Hall, 1983; Misanchuk, 1982, 1984). Further, different data analysis approaches may be applied to data collected using a single technique.

In this paper three approaches to identifying "gaps" and establishing priorities will be explored. These approaches are applied to the analysis of data collected to identify the level of knowledge, skill, or attitude that "SHOULD" exist and the level that "DOES" exist. (For the remainder of the paper, knowledge will be used alone, so repeating skills, attitudes, and other learner characteristics will not be necessary.) Discrepancies between SHOULD and DOES are usually identified through analyzing responses to similar rating scales for the two dimensions and are presumed to identify gaps between the desired state and the current state. Prioritization of needs is accomplished by comparing the magnitude of the discrepancy measure between the ratings on the two dimensions. How the discrepancy is defined may be key to the outcome of the prioritization.

Three Ways to Quantify the Gap

For the purposes of the following discussion, a discrepancy-column questionnaire-type needs assessment instrument is assumed. The discrepancy-column format has been shown to be superior to single-column constructions for needs assessment (Johnson & Dixon, 1984). During instrument development, key content areas would have been identified for assessment. A response pattern of two five-option scales—one to assess a level of knowledge that SHOULD exist and one to assess the level of knowledge perceived to (i.e., DOES) exist—are assumed (see Figure 1). For each content area, respondents mark their rating for the two dimensions. Typically, an opportunity would be afforded for respondents to note additional areas in an "Other" category. The analysis of these added categories is not considered here.

Mean Difference Analysis

The simplest way to analyze data such as these is to sum the ratings for a category by dimension and divide by the number of responses. Thus, a mean for each category is derived for the level that SHOULD exist and for the level that DOES exist. The difference of interest between these two means can be determined by $\overline{X}_S - \overline{X}_D$; where $\overline{X}_S$ = average rating on the SHOULD dimension and $\overline{X}_D$ = average rating on the DOES dimension. A positive difference is indicative of a greater knowledge level needed than currently exists (i.e., a gap). The greater the magnitude of this gap, the higher is the priority of the need.

Multi-Component Data Analysis

Misanchuk (1982, 1984) proposed an application of the statistic del for the analysis of needs assessment data when two or more dimensions are considered simultaneously. While Misanchuk applied the statistic to dimensions of relevance and competence, his logic for using it applies equally well to the somewhat different SHOULD and DOES dimensions. Borrowing from Misanchuk (1984, p. 29): One need only postulate that a high educational need exists when the respondents collectively indicate a high knowledge level SHOULD exist with a concomitant low knowledge that DOES exist. In essence, this statistical approach can be used to identify properties of need by summarizing the discrepancies in response patterns on the SHOULD/DOES continuum, taking into account the magnitude of the rating on the SHOULD dimension. The implicit contention in this approach is that differences of the same magnitude between what SHOULD exist and what DOES exist have different meaning, depending on whether there is a high or low level indicated on the SHOULD dimension.

In Misanchuk's application, two key theoretical assumptions were made by the needs analyst:

1. That the marginal probabilities of the rows and columns of a matrix of SHOULD x DOES ratings are known (or can be reasonably assigned) by the analyst, and

Content Area/ Category	DIMENSION									
	Knowledge Level That Should Exist					Knowledge Level That Does Exist				
	Almost None				Exten-sive	Almost None				Exten-sive
1.	1	2	3	4	5	1	2	3	4	5
2.	1	2	3	4	5	1	2	3	4	5
3.	1	2	3	4	5	1	2	3	4	5
4.	1	2	3	4	5	1	2	3	4	5
5.	1	2	3	4	5	1	2	3	4	5

Figure 1. Response scale facsimile.

2. That a systematic cell weighting scheme, related to a proportionate reduction in error approach to the data analysis can be defined.

These assumptions are explained below.

Data collected for a single content area in an approach as shown in Figure 1 could be displayed in a 5 x 5 matrix as indicated in Figure 2.

Knowledge Level That Does Exist	Knowledge Level That Should Exist: Low 1	2	3	4	High 5	Prob.
Low 1	(1,1)	(1,2)	(1,3)	(1,4)	(1,5)	0
2	(2,1)	(2,2)	(2,3)	(2,4)	(2,5)	.1
3	(3,1)	(3,2)	(3,3)	(3,4)	(3,5)	.2
4	(4,1)	(4,2)	(4,3)	(4,4)	(4,5)	.3
High 5	(5,1)	(5,2)	(5,3)	(5,4)	(5,5)	.4
Prob.	0	.1	.2	.3	.4	

Figure 2. Data matrix for item #1.

Each row and each column of the matrix is assigned a probability to satisfy assumption 1 above. Based on a logical argument that the areas studied in the needs identification process should be "quite relevant to the job roles, and that the process of natural selection that obtains in hiring and firing tends to place more-or-less competent individuals into job roles, it might be reasonable to postulate a monotonically increasing set of proportions as one moves away from the upper left corner of the needs assessment data matrix" (Misanchuk, 1982, p. 11). Thus, a marginal probability scheme of 0, .1, .2, .3, and .4 can be used. These marginal probabilities are shown in Figure 2. Following this scheme the cell probability assumed for a combination of responses indicating that an extremely high level of knowledge SHOULD exist (5) and an extremely low level of knowledge DOES exist (1) would be 0 (.4 x 0 = 0). The probability for a cell representing moderate levels on both dimensions (e.g., 4 on SHOULD and 3 on DOES) would be .06 (.3 x .2 = .06), and so on.

In regard to assumption 2 above, Misanchuk (1982) makes an argument for a cell weighting scheme assuming a "more-or-less linear progression based on a unit diagonal length" (p. 20). In other words, the cell weight for cell (1,5) (low level of knowledge DOES exist and high level of knowledge SHOULD exist) is 0.0000 and a cell weight for cell (5,1) (high DOES and low SHOULD) is 1.0000. Cell (3,3) is weighted .50000, and so on. Each cell is weighted, working off of this unit-diagonal scheme (see Appendix A for complete table of cell weights).

The weights can be conceptually understood as the individual cell contribution to an indication of *no need for training*. That is, if a person's response appears in cell (5,1), it is assumed that there is absolutely no need for training (weight = 1.0000). If, on the other hand, the person's response places them in cell (4,2), it is assumed there may be some, but very little need (weight = .7500). In still another example, for cell (2,5), it is assumed that there is little contribution to the *no need* conclusion, thus there is a low weight for the cell (weight = .1768).

Employing Misanchuk's (1982) proposed cell weighting scheme and assumption of monotonically increasing proportions for the marginals, the formula actually employed in this study (using Δ N to denote the needs assessment del was:

$$\nabla_N = 1 - \frac{\sum_{i=1}^{R} \sum_{j=1}^{C} W_{ij} P_{ij}}{.5729},$$

Where: W_{ij} is the weight for cell (i,j) (see Appendix A for weights used); P_{ij} is the probability of a randomly sampled observation falling into cell (i,j); .5729 is a constant derived from the application of the noted assumptions.

The value of ΔN as computed can range from approximately -1.75 to 1, with any negative value indicating *no need*. The values of del ranging from 0.00 to 1 can be interpreted as carrying magnitudes of need and can be used to prioritize the needs. This method of analysis gives heavier emphasis in the prioritization process to areas which many respondents feel there SHOULD be high levels of knowledge, but for which lower levels of knowledge exist.

Weighted Needs Index

When an organization considers building training programs to benefit its long-term success, the training should be developed only for critical skills, knowledge, or attitudes and for severe deficiencies. This implies a threshold of relevance, importance or "SHOULD" below which no training would be economically justified even though a discrepancy exists. Further, it implies a threshold above which the level of competence or existing knowledge is deemed to be adequate (i.e., not worth the cost to refine or hone through formal training programs). Within the thresholds it is important to be able to prioritize content areas according to the severity of the need.

In addition, the needs assessment analyst must sometimes communicate with an audience that is neither well-versed in nor impressed with statistics. This audience may be skeptical of assumptions about "monotonically increasing marginal probability" or "unit diagonal linear progression," but might embrace the logic which suggest that small discrepancies for important skills may need to be addressed, whereas relatively larger discrepancies for less important skills may not require attention.

The weighted needs index (WNI) was developed to incorporate the threshold concept into an easy to communicate and directly intuitive data analysis approach. The WNI uses a cell-weighted scheme to transform frequency data into a single, important-weighted score for each content area assessed. This value is then used to prioritize the areas according to the magnitude of need.

The WNI focuses on those areas receiving a SHOULD rating of 3 or higher and a DOES rating of 3 or lower. The implicit assumptions in the algorithm is that the relative ratings of SHOULD and DOES show no need for training development (from an organizational point of view) if there is no discrepancy in rating or if the SHOULD rating fails to meet a test of "moderate to high" in conjunction with "moderate to low" DOES. The weighting value assignment scheme is shown in Figure 3. The higher values here are indicative of *greater need for training* development.

DOES \ SHOULD	1	2	3	4	5
1	0	0	3	4	5
2	0	0	1	2	4
3	0	0	0	1	3
4	0	0	0	0	0
5	0	0	0	0	0

Figure 3. Cell value assignment scheme used in the weighted needs algorithm.

Values 1 through 5 have been assigned to the various response combinations of interest, based on the assumption of increasing need for training as the discrepancy between SHOULD and DOES in this range becomes greater. Weights of zero have been entered in the cells in Figure 3 that have been operationally defined as beyond the thresholds.

The formula for calculation is:

$$\text{Weighted Needs Index} = \frac{\sum_{i=1}^{3} \sum_{j=3}^{5} f_{ij} V_{ij}}{N}$$

Where: f_{ij} = frequency of responses in a given cell (i=rows, j=columns), and
V_{ij} = the assigned value for the given cell
N = total number of people responding to the item.

This index value can be viewed simply as an average, importance-weighted rating of need. Index values can range from 0 to 5, and the higher the value the greater the implied need for training.

A Comparison Study

Each of the three data analysis techniques has claimed advantages and disadvantages. The mean difference approach is the simplest to calculate and easiest to describe to an audience that is not well versed in or is even skeptical of statistical analyses. On the other hand, it requires an assumption that the rating scales yield interval data and fails to take into account differences in the absolute importance level of the variable. The data user under mean difference analysis must attend to both the rating for "SHOULD" (i.e., importance) and to the difference between "SHOULD" and "DOES" in interpreting the results, an increasing problem as the number of discrepancies to be prioritized increases.

The multi-component data analysis takes into account the importance level and the difference between "SHOULD" and "DOES," and represents the results in a single number. This reduces the interpretation complexity, since the user has to attend to only one number, a distinct advantage when several areas are assessed in one questionnaire. It, however, is conceptually and computationally complex and therefore more difficult to "sell" to some audiences. It also includes results that are additive across the entire distribution of responses, and does not treat responses above or below any given threshold differently. (This is not entirely the case since "errorless" cells in the computation may be designated.) This latter characteristic is a key advantage to the multi-component approach, when there is a prior assumption that costjustifiable benefits exist in providing training at any level of importance or competence if the discrepancy is significant.

Finally, the weighted needs index is an approach somewhat different from the other two approaches in some significant respects. It is computationally less complex and requires fewer theoretical assumptions than multi-component analysis. It accounts for threshold levels of knowledge that SHOULD and DOES exist in the analysis and represents the need hierarchy in a single number.

This study was undertaken to assess the relative effects of these three data analysis approaches on prioritizing needs, when resources are a significant constraint on training development. A needs assessment was undertaken to define a training curriculum to increase competence of management and professional staff working with construction industry clients of a large accounting/auditing firm. A core group of industry experts, with specialties in accounting/auditing, tax consulting, and management information systems consulting, was used to develop a list of content areas for which training was deemed to be potentially very important. The content areas identified included 18 business issues and seven accounting/audit issues uniquely related to construction industry work. These 25 issues were included as part of a more comprehensive survey administered to managers and professional staff.

Sample

Two hundred forty-seven surveys were distributed to industry managers and professional staff actively engaged in construction industry work. One hundred sixty-three of the surveys (86 from managers and 77 from professional staff) were returned after two follow-up reminders to nonrespondents. The usable return rate was approximately 66 percent. The sample was distributed throughout the United States, with a small representation from outside the U.S.

Survey

On the survey instrument, respondents were asked to answer the following questions for each content area.

1. "Indicate the knowledge level that *should* exist for individuals who are working with construction industry clients. Please rate each issue for persons at your personnel classification."
2. "Indicate the knowledge level that *does* exist for individuals who are working with construction industry clients. Please rate YOUR own knowledge level."

The instrument was set up in the format shown in Figure 1 above. Respondents indicated their assessments by circling the number most closely corresponding to their judgments for each issue listed. Responses were coded and keypunched. The data analyses were conducted using the Statistical Analysis System (SAS).

Data Analyses

The data analyses were conducted separately for managers and professional staff. First, means were computed using all available responses for each issue on the two dimensions (knowledge level that SHOULD exist and knowledge level that DOES exist). The difference between means was computed for each issue, and the issues were ranked according to the magnitude of the mean difference.

In a second analysis, ΔN as described above was computed for each issue. This analysis made use of SAS to output the 5x5 cell matrices illustrated in Figure 2, then through additional programming, computations of ΔN were accomplished. The resulting values served as the basis for a second ranking of the issues into priority order.

In the third analysis the weighted needs index was used to produce a score for each issue. Again SAS with additional user programming was used. The issues were prioritized according to the weighted needs index.

Results and Discussion

In a strict sense, the results of the needs assessment were influenced by the data analysis technique applied. If content areas were selected for training development solely on the basis of questionnaire results, the differences that would have occurred in the two samples used in this study are shown in Table 1. The table shows the percent of agreement between the data analysis techniques at the two personnel levels when constraints are placed on the number of content areas to be addressed. For example, if resources were available in the firm to address only five of the 25 content areas studied, there would be agreement on four of the five (80%) areas regardless of whether the mean difference analysis approach or the multi-component data analysis approach was used. There would be complete (100%) agreement between the mean difference approach and the weighted needs index, and consequently 80% agreement between the multi-component and weight needs approaches. As would be predictable from the computational approaches, there is generally better agreement between the mean difference and weighted needs approaches and between

Table 1. Percent of Agreement among Data Analysis Results under Constrained Response to Needs.

# of areas to be addressed	Minimum Percent Agreement: MDA vs. ∇N		MDA vs. WNI		∇N vs. WNI	
	Mgr.	Staff	Mgr.	Staff	Mgr.	Staff
2	100	50	100	50	100	50
3	67	67	100	67	67	67
5	80	80	100	100	80	80
10	90	80	90	80	90	90
15	93	87	100	93	93	93
Average across various levels	86	73	98	80	86	76

NOTE: ∇_N = Needs assessment del
MDA = Mean Difference Analysis
WNI = Weighted Needs Index

the multicomponent and weighted needs approaches, than there is between the mean difference and multi-component approaches. Also, as the proportion of content areas to be addressed increases, there appears to be generally increasing agreement among all three approaches. This trend also is predictable, but might not have been intuitively expected to increase as rapidly as it appears in these samples. For example, by the time 40% of the content areas were included, there was uniformly 80% to 90% agreement among the three data analysis approaches.

In Table 2, the number of respondents to each issue (N) and the results of the data analyses for each of the three different approaches, by personnel level are shown. The content areas are labeled by letter, in the sequence they appeared on the original questionnaire.

Overall, the relationships between the various analysis approaches for the two personnel samples on the 25 content areas studied were quite high. Rank order correlations of .92, .94, and .95 were found for mean difference vs. multi-component, mean difference vs. weighted needs index, and multi-component vs. weighted needs index, respectively, for the manager group. The comparable correlations for the professional staff group were .85, .92, and .95.

The similarities in results of the three approaches are further evidenced in an analysis of the effects of the importance (SHOULD) ratings on the results. For each sample (managers and professional staff) an analysis was undertaken to assess whether differences in ranks obtained by the three approaches were systematic. The issues were rank ordered by magnitude of the SHOULD dimension. Then, the relative need was compared, based on ranks of issues analyzed by the three computational approaches. For example, the highest ranked issue on the SHOULD dimension for managers was content area "G," but its respective ranks of need under the three analysis approaches were 13.5, 18, and 15. If the more important content areas are likely to be favored by the multicomponent and the weighted needs models, as might be inferred from the earlier discussions, then differences in the rankings should be systematic with the mean difference approach yielding lower priority needs at the higher "SHOULD" levels and higher needs at the lower "SHOULD" levels than the other approaches. An analysis of the data, using the one sample runs test (Siegel, 1956) indicated that the order of the observed differences in both samples was randomly occurring. In other words, the rankings in these samples were not systematically related to the importance (SHOULD) ratings. It should be noted, however, that all of the 25 content areas studied here showed some positive level of need and all were judged relatively important (average ratings of SHOULD ranged from 3.42 to 4.63 in the two samples). A set of content areas or issues which yielded a wider range of reactions might have shown systematic relationships that were not apparent here.

Table 2: Actual Values and Priority Ranks Yielded for Each of Three Data Analysis Approaches

	Managers				Professional Staff			
Content Area	N	Mean Difference (Rank)	DEL (Rank)	Weighted Needs Index (Rank)	N	Mean Difference (Rank)	DEL (Rank)	Weighted Needs Index (Rank)
A	84	.60 (25)	.1775 (17)	.7143 (18)	76	.54 (25)	.2069 (25)	.5921 (25)
B	84	.91 (15)	.1980 (15)	.8929 (14)	76	.86 (21.5)	.2785 (20)	.8947 (21)
C	82	.66 (22.5)	.1038 (25)	.4634 (25)	77	.71 (23)	.2227 (24)	.7662 (23)
D	82	.66 (22.5)	.1287 (20)	.5122 (24)	76	86 (21.5)	.2803 (19)	.9079 (19)
E	81	.68 (21)	.1203 (22)	.6173 (22)	77	.66 (24)	.2310 (23)	.7013 (24)
F	83	1.04 (12)	.2096 (14)	1.0482 (12)	74	1.19 (9)	.3202 (14)	1.2297 (11)
G	83	.97 (13.5)	.1624 (18)	.8795 (15)	76	1.22 (6)	.3051 (17)	1.1579 (16)
H	82	.72 (19)	.1347 (19)	.6707 (19)	73	1.09 (15.5)	.3120 (16)	1.1644 (15)
I	84	1.07 (10.5)	.2444 (12)	1.0952 (11)	74	1.34 (2.5)	.4141 (4)	1.4595 (4)
J	84	1.15 (5)	.2783 (9)	1.3214 (5)	75	1.17 (11)	.3392 (11)	1.2000 (13.5)
K	82	1.07 (10.5)	.3185 (7)	1.1707 (7)	72	1.19 (9)	.3719 (8)	1.3333 (6)
L	81	1.11 (8)	.3714 (3)	1.1604 (8)	75	.98 (20)	.3170 (15)	.9733 (18)
M	82	1.12 (7)	.3195 (6)	1.1463 (9)	75	1.13 (13.5)	.3949 (6)	1.2267 (12)
N	85	1.44 (1)	.4337 (2)	1.7412 (1)	77	1.13 (13.5)	.4214 (3)	1.2987 (7)
O	79	1.09 (9)	.2738 (10)	.9620 (13)	75	1.09 (15.5)	.3269 (13)	1.2000 (13.5)
P	82	1.19 (4)	.3668 (4)	1.3537 (4)	76	1.31 (4)	.4023 (5)	1.5789 (2)
Q	84	1.27 (3)	.3409 (5)	1.4405 (3)	75	1.21 (7)	.3859 (7)	1.2933 (8)
R	83	1.41 (2)	.4463 (1)	1.5181 (2)	77	1.34 (2.5)	.4675 (1)	1.4675 (3)
S	84	.65 (24)	.1085 (24)	.6190 (20.5)	76	1.01 (18)	.2455 (21)	.8553 (22)
T	83	.73 (18)	.1246 (21)	.5301 (23)	75	.99 (19)	.2439 (22)	.9067 (20)
U	84	.69 (20)	.1147 (23)	.6190 (20.5)	76	1.07 (17)	.2806 (18)	1.0790 (17)
V	84	1.13 (6)	.2867 (8)	1.2381 (6)	74	1.19 (9)	.3418 (10)	1.2432 (10)
W	83	.89 (16)	.2191 (13)	.8675 (16)	76	1.23 (5)	.3681 (9)	1.4342 (5)
X	82	.86 (17)	.1826 (16)	.8547 (17)	76	1.14 (12)	.3323 (12)	1.2500 (9)
Y	81	.97 (13.5)	.2477 (11)	1.0988 (10)	76	1.39 (1)	.4412 (2)	1.5921 (1)

Summary and Conclusions

A study of training needs was undertaken, using a questionnaire to assess the level of knowledge that SHOULD exist and the level of knowledge that DOES exist for 25 content areas. The data were analyzed by three different approaches: mean difference analysis, multi-component data analysis, and weighted needs index.

The study included a relatively small sample of content areas and small samples of respondents. This, however, probably represents the "real world" of needs assessment. The results for these samples were fairly homogeneous. All 25 areas were identified as yielding a positive need for training development. Future research should focus on a broader range of needs and on larger and more diverse samples of respondents and content areas. It should also include exploration of the consequences of adopting a "threshold" approach as suggested by WNI and development of decision rules to guide the analyst in setting threshold levels realistically.

Two conclusions based on the forgoing discussion and the study results seem tentatively warranted. First, if a significant portion of the content areas considered in a needs assessment are likely to be addressed, and if each area individually represents a relatively harmless consequence if included or omitted in error, it appears that any of these approaches to the data analysis task would probably be adequate. If, however, a relatively small proportion of the areas can be addressed, analyses using ΔN or WNI should be conducted. Secondly, because of the different assumptions underlying ΔN and WNI, the selection of one over the other depends on the training intent. If the focus is one of providing training at any importance or competence level when there is an identified need, then ΔN may be preferred. On the other hand, if thresholds beyond which no training will be developed should be established, WNI may better serve the decisions to be made.

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Appendix A

Weights Used in the Analysis of Multi-Component Training Needs Data

	Not Important		Relevance		Very Important
Very Poorly	.7071	.5303	.3536	.1768	0.0000
Competence	.7289	.5590	.3953	.2500	.1768
	.7906	.6374	.5000	.3953	.3536
	.8839	.7500	.6374	.5590	.5303
Very Well	1.0000	.8839	.7906	.7289	.7071

Suggested error weights. For simplicity, a more-or-less linear progression (based on a unit diagonal length) is suggested, although other patterns could be proposed for specific purposes. For all practical purposes, weights could be rounded to two significant figures. (From Misanchuk, 1982)