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# The Cognitive Domain of the Quality of Life of University Students: A Re-Analyses of an Instrument

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# The Cognitive Domain of the Quality of Life of University Students: A Re-Analyses of an Instrument

## ABSTRACT

This paper presents the re-analysis of a previously published instrument, based on Bloom's taxonomy, developed to measure the cognitive domain of the quality of life of university students. The items in this instrument were assessed using Guttman's

Smallest Space Analysis. The findings generally support Bloom's conceptualization, identifying 5 of 6 dimensions in the taxonomy: Knowledge, Comprehension, Application, Analysis, and Evaluation. The findings provide support for the enduring utility of Bloom's taxonomy, and reinforce the ongoing need to test theoretically informed instruments using sophisticated statistical techniques.

# The Cognitive Domain of the Quality of Life of University Students: A Re-Analyses of an Instrument

## INTRODUCTION

Developing accurate and empirically verifiable scales to measure attitudes has been a longstanding concern of social scientists. Scales that measure attitudes pertaining to "quality of life" have proven especially difficult, given the highly abstract nature of the target concept. Criticism of the existing literature on quality of life scales typically highlights deficiencies in conceptualization and/or the unsophisticated statistical techniques used this work.

Several years ago, a team of Canadian researchers developed scales to measure the quality of life of university students, which consisted of comprehensive questionnaires capturing both the affective and the cognitive domains of students' quality of life (Clifton et al. 1996; Roberts et al. 1992). These instruments were conceptually informed and relied on rigorous empirical testing to establish their reliability and validity. The impressive psychometrics and research utility of these scales have led to their adoption and use in several projects across various countries.

Despite the utility of these Canadian researchers' scales, the outcome of their reliance on Bloom's taxonomy (Bloom et al. 1956) for the measures in the cognitive domain was somewhat disappointing. Specifically, these researchers were only able to extract and identify two dimensions in the cognitive domain, even though they constructed the scale items to include all six of the dimensions in Bloom's taxonomy. The two dimensions that emerged included a Structural dimension and a Functional dimension (Clifton et al. 1996). The Structural dimension included Bloom's knowledge and comprehension measures, while the Functional dimension included measures from the application, analysis, synthesis, and evaluation categories.

The failure of Clifton et al.'s (1996) effort to reconstruct the six dimensions of Bloom's taxonomy in their quality of university student life scales can be interpreted in different ways. One position is to argue that the fundamental attitudes and values of students have changed extensively in recent years, making Bloom's taxonomy less relevant now than when it was constructed several decade ago. The work of Nevitte (1996) and Inglehart (1997), for example, provide strong support for the credibility of this potential interpretation. On the other hand, a huge research literature continues to use and support the credibility of Bloom's taxonomy (see, for example, Ayersman 1995; Booth 1994; Chittum et al. 1996; Cox and Unks 1967; Cox and Wildemann 1970; Hancock 1994; LeSure et. al. 1993; Livingston and Gentile 1996; Minor and Benbow 1996; Stanley 1997; White 1997; Whitfield 1994; and Woloshyn and Rye 1995).

Only a prolonged period of future research will help sort out which of these positions about the continued credibility of Bloom's taxonomy is more sustainable. In the interim, however, this paper proceeds from the supposition that, before discarding a rich conceptual tradition, a re-evaluation of existing research using state of the art analysis techniques is worthwhile. The remainder of this article reports the attempt to use Smallest Space Analysis to gain a clearer estimation of the dimensions of the cognitive domain of the quality of life of university students.

## ORIGINAL METHODOLOGY AND POTENTIAL PROBLEMS

Clifton et al. (1996) identified items designed to measure the cognitive domain of the quality of university student life and tested these items on a representative sample of undergraduate students at a major Canadian university. The sample was selected using a stratified random cluster procedure. Questionnaires were distributed to students attending selected classes. Following this procedure, two hundred and sixty-nine questionnaires were completed, which provided an adequate sample for developing and validating an instrument to measure the quality of life of students.

To conceptualize the quality of university student life in the cognitive domain, Clifton et al., (1996) created 36 items to represent the six theoretically distinct dimensions of

Bloom's taxonomy (Knowledge, Comprehension, Application, Analysis, Synthesis, and Evaluation). In attempting to confirm that the items represented these six theoretical dimensions, a series of factor analyses were conducted with the expectation that the items would load on six distinct factors. The analyses failed to reproduce the anticipated six factors. As noted earlier, the authors discovered only two identifiable factors (Structure and Function), and these emerged only after three items from the Comprehension dimension were eliminated because they consistently loaded on more than one factor.

Potentially, there are technical and methodological reasons why these authors were unable to replicate Bloom's six dimensions in their analysis. The following sections discuss each of these possibilities and present a re-examination of the instrument for measuring the quality of university student life.

## THE RE-EXAMINATION

### *A Re-Analysis of the Instrument*

Clifton et al. (1996) used classical factor analyses to identify the scale dimensions. Recent research (Borg 1999; Cohen 1995, 1997, in press, Stashevski, and Elizur 1999) suggests a more appropriate analysis procedure may involve Smallest Space Analysis.

Based on Louis Guttman's (1968, 1982) Facet Theory Analyses, Smallest Space Analysis (SSA) is a specific multidimensional scaling procedure developed to "... portray the data's structure in a spatial fashion easily assimilated by the relatively untrained human eye. [Researchers] construct a geometric representation of the data…. The essential ingredient defining all multidimensional scaling methods is the spatial representation of data structure" (Young 1987:3). SSA analyzes a matrix of correlations between n items by graphically representing them as points in a Euclidean space called the "smallest space." The points are plotted according to an intuitively-understood principle: the higher the correlation between two items, the closer they are on the smallest space map and, conversely, the lower the correlation, the further apart they are on the map (Guttman 1968; Levy 1994)[1]. A number of researchers, including Guttman, have used this procedure to study the attitude and well-being of people in a variety of organizational contexts (see, Cohen 1992, 1995, 1997, 1999; Levy and Guttman 1976).

The re-analysis began by analyzing Clifton et al.'s (1996) Pearson Product Moment Correlation Matrix, reported in Table 1, using SSA. In both confirmatory factor analysis and smallest space analysis, researchers look for an organization of the items into dimensions according to the theoretical conceptualization. However, while factor analysis is based on linear mathematics, SSA is based on monotonous mathematics (see, Borg 1981; Borg and Groenen 1997; Coxon 1982; Davison 1983; Kruskal and Wish 1978; Lingoes et. al. 1979; Schiffman et. al 1981; Young 1987). Figure 1 presents the results of the initial SSA analysis.

Table 1

Figure 1

In fact, this figure illustrates that SSA is more effective in portraying the data in terms of Bloom's conceptualization than the factor analysis used in the original quality of university student life analysis. In order to interpret this computer-generated map in terms of its theoretical foundation, we look for contiguous regions that specifically and exclusively include items of the same domain. Where this is possible, the interpretation is that the population in the study distinguishes between the various domains.

Figure 1 clearly shows four regions on the conceptual map, three of which correspond to the Knowledge, Comprehension, and Evaluation dimensions of the cognitive domain. Furthermore, the configuration of the four regions in this map correspond to the logic of the theory, with the basic dimension (Knowledge) on the right-hand side and the regions progressing in order of complexity to the Evaluation dimension on the left-hand side. Although this initial mapping is superior to the two dimensions identified in the Clifton et al. (1996) analysis, the map nonetheless contains some ambiguity. Three of Bloom's dimensions (Application, Analysis, and Synthesis) seem to form one mixed region.

From this initial smallest space analysis the two lowest order domains in Bloom's taxonomy, as well as the most complex one, are readily distinguishable, while the three intermediate domains are not [2].

In order to improve on this result, the items comprising each of the dimensions were examined on the assumption that some items may not accurately portray the theoretical dimensions they were designed to measure. In an effort to identify such items, six Pearson Correlation Matrices were produced, one for each of Bloom's six dimensions. The six Correlation Matrices are reported in Panels A to F in Table 2.

Table 2

In examining these matrices, it is obvious that the correlations in the Synthesis dimension (Panel E) are lower than those in the other five dimensions. Its weakest correlation is lower than the weakest of any other domain, and its strongest is weaker than the strongest of the others. Specifically, the lowest correlation between items in the Synthesis dimension is 0.09. The next lowest correlation in another dimension is 0.12, in the Comprehension dimension. In turn, the highest correlation in the Synthesis dimension is 0.39 while the next lowest of the each dimensions highest correlation is 0.48, in the Evaluation dimension.

These differences are substantial and, on this basis, the decision was taken to run another SSA analysis on a single Pearson Correlation Matrix, this time excluding en bloc the six items Clifton et al. (1996) designed to measure the Synthesis dimension. The results are presented in Figure 2, where all five of the remaining dimensions of the cognitive domain (Knowledge, Comprehension, Application, Analysis, and Evaluation) can clearly be distinguished.

Figure 2

Figure 2 indicates that, again, the Knowledge, Comprehension, and Evaluation regions are the most cohesive. At first glance, the Application and Analysis items appear to form one region, but on closer inspection, it is possible to delineate between the dimensions. What this analysis indicates is that, with the exception of the Synthesis dimension, SSA is able to detect a theoretically aligned structure in a way that the Clifton et al. (1996) were unable to do [3].

*A Re-Analysis of the Methodology*

Although the application of SSA yields improved results, it is somewhat disappointing that this outcome required the exclusion of items measuring the Synthesis domain. Consequently, a methodological re-analysis was conducted to determine why the Synthesis items are so weakly correlated and why they create so much noise in the SSA map.

It is possible that the low correlations between these measures indicate methodological problems in the construction of the items. For example, ambiguous wording in the questionnaire may have confused the respondents. Alternately, inappropriate items (i.e. ones that do not actually represent the Synthesis dimension) may cause items expected to appear in the Synthesis region to be located in other regions. In addition, it is also possible that there is a deeper, theoretical problem with the Synthesis domain. Bloom et al. (1971: 193-204) defined Synthesis and gave samples of empirical measures. Organizing ideas, designing plans, producing and communicating original ideas, and proposing ways to solve problems are all concepts that appear in this summary of the Synthesis dimension. When Bloom's conceptualization is compared to the content of the Synthesis items in the Clifton et al. (1996) quality of university student life scales, it is clear that the questionnaire items are in line with Bloom's concept of Synthesis. Therefore, our attention turned to an examination of the wording of the items in the Synthesis dimension.

The wording of the Synthesis items was examined to determine if the verbs used could have possibly influenced the way the students responded to the items. A lack of continuity in the use of verbs may help explain the ambiguities observed in the SSA map. In the Synthesis dimension, five verbs were used in the six scale items. This contrasts to the use of only two verbs in the items for the Knowledge dimension and the three verbs used in the items for the Comprehension dimension. Although verification would require an additional survey, it is possible that the larger number of verbs used in the Synthesis items could contribute to the inconsistency in students' responses to these items, leading to low correlations between the items and noise in the SSA map. This conclusion gains plausibility from a review of the literature which shows the longstanding difficulties researchers in this field have had in adequately constructing items to capture Bloom's taxonomy (Schrag 1989; Seddon 1978; Fairbrother 1975; Smith 1968; Kropp and Stoker 1966; French, Ekstrom and Price 1963).

## CONCLUSION

This article re-examined a well-designed and widely used instrument for measuring the cognitive domain of the quality of university student life (Clifton et al, 1996). It was determined that the original authors' findings could be substantially improved through the use of a more sophisticated analytical procedure, Smallest Space Analysis. This improvement was indicated through a much closer empirical alignment with the dimensions of Bloom's taxonomy that guided the construction of the instrument.

Although the re-analyzed results displayed a much better fit with Bloom's multidimensional framework, one dimension (Synthesis) continued to be problematic. This dimension contained low correlations between items, which resulted in extensive noise in the smallest space mapping. A close inspection of the items composing the Synthesis dimension indicates that the diversity of verbs used in the wording of the items may have contributed to the dimension's ambiguity in the map.

In contrast to the initial interpretation that Clifton et al. (1996) gave to their findings, this re-analysis supports the idea that modern university students do distinguish between the different types of cognitive challenges that has been conceptualized by Bloom taxonomy. This result reinforces the continuing need to triangulate educational research conclusions through the application of sophisticated analysis techniques. Future research on these quality of life scales needs to concentrate on recasting and testing the items included in the Synthesis dimension. If this dimension can be successfully measured then a full alignment of a scale with Bloom's taxonomy is possible.

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## NOTES

1- The specific statistical package use to perform the reanalysis (HUDAP) was developed at the Hebrew University in Jerusalem (Guttman 1968; Guttman 1982; Levy 1994; Canter 1985). HUDAP was programmed by Reuven Amar and Shlomo Toledano from the Calculation Centre of the Hebrew University of Jerusalem. This package is the only one to provide users with analytical methods which are based on the principles of Facet Theory identified by the late Prof. Louis Guttman.

2 - In an attempt to improve on this result, another Smallest Space Analysis was conducted using a Monotonicity Correlations, regression-free coefficients of correlation (Guttman 1986: 80-87). This is the correlation procedure preferred by the creator of the SSA that has yielded good results in other studies using SSA. However, in this case, the results were almost identical to those based on the Pearson Correlation Matrix. After closely examining both analyses, we concluded that the Pearson-SSA analysis is more appropriate for Bloom's conceptualization than the MONCO-SSA analysis, and we proceeded to continue working from those results. Consequently, the results of the MONCO-SSA analysis are not reported in this paper, although they are available from the senior author.

3 - Despite repeated attempts, it was not possible to include the items used to measure the Synthesis dimension in a coherent mapping. We created separate 2 x 2 matrices and corresponding SSA maps for Synthesis and each of the other dimensions, in order to pinpoint the particular sources of the noise seen in the Synthesis mapping. Clear distinctions were found between Synthesis and Knowledge, Synthesis and Comprehension, and Synthesis and Application. In addition, it was possible to separate Synthesis and Analysis into contiguous regions, but with a roundabout, curving border between them. Synthesis and Evaluation cannot be divided into separate, contiguous

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## Table 1: Pearson Product Moment Correlation Matrix of the 36

I N P U T   M A T R I X *

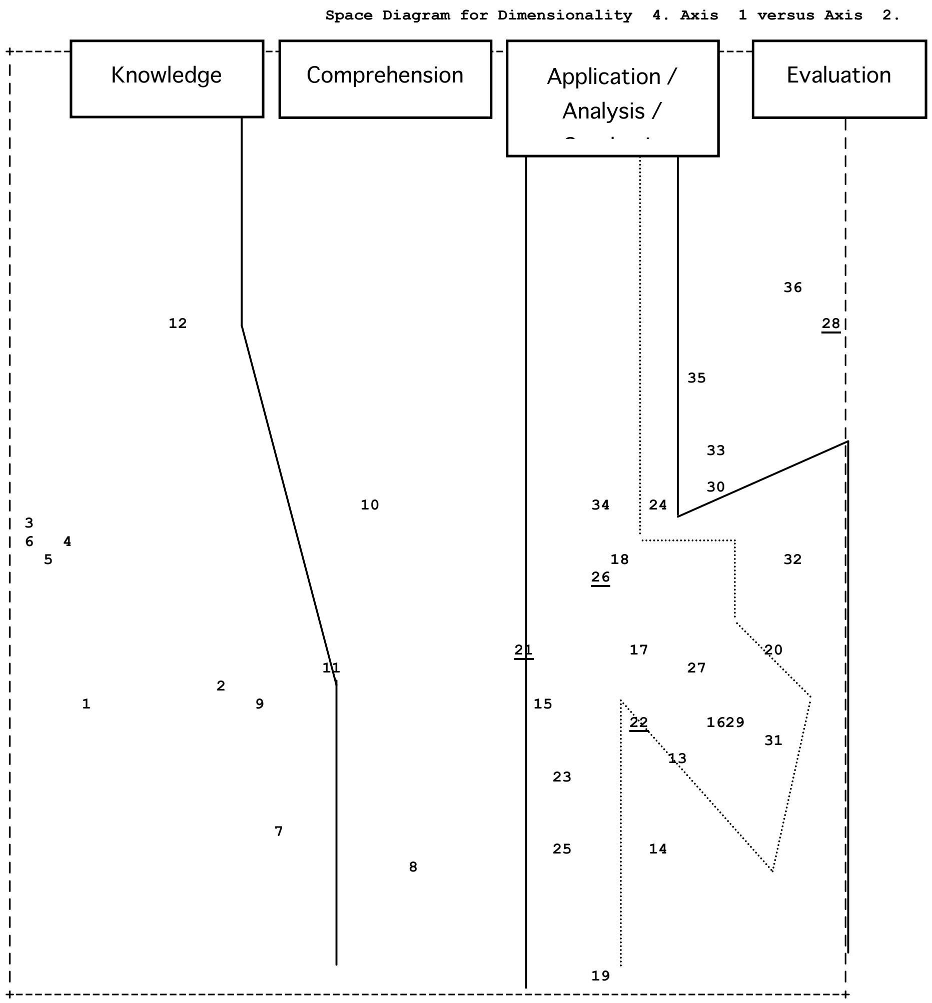
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| remember new terms | 1 | 100 | 59 | 52 | 59 | 52 | 57 | 43 | 30 | 36 | 33 | 34 | 28 | 19 | 19 | 26 | 8 | 16 | 20 | 23 | 11 | 20 | 19 | 22 | 9 | 16 |
| recall a substantial | 2 | 59 | 100 | 50 | 53 | 49 | 46 | 42 | 47 | 42 | 46 | 34 | 27 | 21 | 23 | 34 | 15 | 28 | 22 | 36 | 18 | 38 | 27 | 38 | 21 | 32 |
| recall a lot of factual | 3 | 52 | 50 | 100 | 74 | 76 | 69 | 26 | 22 | 36 | 34 | 32 | 26 | 6 | 6 | 16 | 1 | 11 | 14 | 8 | 5 | 24 | 16 | 9 | 10 | 12 |
| remember an extensive nu | 4 | 59 | 53 | 74 | 100 | 81 | 78 | 28 | 21 | 40 | 39 | 37 | 29 | 9 | 10 | 20 | 7 | 19 | 15 | 7 | 8 | 24 | 15 | 17 | 9 | 11 |
| recall a significant num | 5 | 52 | 49 | 76 | 81 | 100 | 77 | 28 | 24 | 44 | 35 | 38 | 32 | 3 | 7 | 21 | 11 | 18 | 16 | 12 | 12 | 26 | 17 | 20 | 13 | 13 |
| remember complex facts | 6 | 57 | 46 | 69 | 78 | 77 | 100 | 28 | 23 | 41 | 35 | 41 | 39 | 9 | 12 | 18 | 7 | 15 | 17 | 8 | 3 | 21 | 15 | 13 | 10 | 11 |
| translate ideas | 7 | 43 | 42 | 26 | 28 | 28 | 28 | 100 | 49 | 33 | 39 | 53 | 16 | 24 | 28 | 26 | 17 | 24 | 16 | 27 | 19 | 37 | 24 | 27 | 23 | 23 |
| translate concepts | 8 | 30 | 47 | 22 | 21 | 24 | 23 | 49 | 100 | 32 | 33 | 54 | 16 | 28 | 31 | 31 | 32 | 34 | 22 | 32 | 35 | 43 | 33 | 38 | 28 | 28 |
| interpret meaning of new | 9 | 36 | 42 | 36 | 40 | 44 | 41 | 33 | 32 | 100 | 32 | 45 | 12 | 26 | 24 | 40 | 22 | 33 | 18 | 24 | 17 | 34 | 29 | 36 | 23 | 28 |
| understand difficult ide | 10 | 33 | 46 | 34 | 39 | 35 | 35 | 39 | 33 | 32 | 100 | 42 | 22 | 34 | 23 | 33 | 29 | 40 | 34 | 21 | 26 | 43 | 29 | 38 | 38 | 25 |
| translate a variety of t | 11 | 34 | 34 | 32 | 37 | 38 | 41 | 53 | 54 | 45 | 42 | 100 | 19 | 28 | 29 | 33 | 30 | 42 | 32 | 16 | 30 | 39 | 35 | 40 | 33 | 20 |
| interpret the meaning of | 12 | 28 | 27 | 26 | 29 | 32 | 39 | 16 | 16 | 12 | 22 | 19 | 100 | -3 | 10 | 10 | 14 | 10 | 26 | 9 | 12 | 24 | 18 | 7 | 13 | 7 |
| demonstrate how theories | 13 | 19 | 21 | 6 | 9 | 3 | 9 | 24 | 28 | 26 | 34 | 28 | -3 | 100 | 51 | 41 | 42 | 48 | 43 | 38 | 36 | 38 | 32 | 34 | 23 | 22 |
| use theories to practica | 14 | 19 | 23 | 6 | 10 | 7 | 12 | 28 | 31 | 24 | 23 | 29 | 10 | 51 | 100 | 37 | 49 | 46 | 37 | 37 | 37 | 57 | 40 | 36 | 20 | 24 |
| illustrate abstract idea | 15 | 26 | 34 | 16 | 20 | 21 | 18 | 26 | 31 | 40 | 33 | 33 | 10 | 41 | 37 | 100 | 48 | 44 | 32 | 28 | 36 | 38 | 46 | 46 | 32 | 32 |
| use theoretical ideas to | 16 | 8 | 15 | 1 | 7 | 11 | 7 | 17 | 32 | 22 | 29 | 30 | 14 | 42 | 49 | 48 | 100 | 60 | 41 | 27 | 49 | 47 | 47 | 46 | 33 | 24 |
| apply theories to new si | 17 | 16 | 28 | 11 | 19 | 18 | 15 | 24 | 34 | 33 | 40 | 42 | 10 | 48 | 46 | 44 | 60 | 100 | 51 | 28 | 53 | 46 | 53 | 57 | 41 | 25 |
| apply theoretical princi | 18 | 20 | 22 | 14 | 15 | 16 | 17 | 16 | 22 | 18 | 34 | 32 | 26 | 43 | 37 | 32 | 41 | 51 | 100 | 22 | 47 | 39 | 49 | 39 | 40 | 11 |
| identify organizing | 19 | 23 | 36 | 8 | 7 | 12 | 8 | 27 | 32 | 24 | 21 | 16 | 9 | 38 | 37 | 28 | 27 | 28 | 22 | 100 | 25 | 32 | 34 | 29 | 19 | 45 |
| identify the reasoning u | 20 | 11 | 18 | 5 | 8 | 12 | 3 | 19 | 35 | 17 | 26 | 30 | 12 | 36 | 37 | 36 | 49 | 53 | 47 | 25 | 100 | 39 | 53 | 48 | 32 | 19 |
| analyze complex interrel | 21 | 20 | 38 | 24 | 24 | 26 | 21 | 37 | 43 | 34 | 43 | 39 | 24 | 38 | 57 | 38 | 47 | 46 | 39 | 32 | 39 | 100 | 48 | 37 | 35 | 26 |
| identify assumptions und | 22 | 19 | 27 | 16 | 15 | 17 | 15 | 24 | 33 | 29 | 29 | 35 | 18 | 32 | 40 | 46 | 47 | 53 | 49 | 34 | 53 | 48 | 100 | 51 | 42 | 33 |
| identify the basic ideas | 23 | 22 | 38 | 9 | 17 | 20 | 13 | 27 | 38 | 36 | 38 | 40 | 7 | 34 | 36 | 46 | 46 | 57 | 39 | 29 | 48 | 37 | 51 | 100 | 31 | 28 |
| illustrate how different | 24 | 9 | 21 | 10 | 9 | 13 | 10 | 23 | 28 | 23 | 38 | 33 | 13 | 23 | 20 | 32 | 33 | 41 | 40 | 19 | 32 | 35 | 42 | 31 | 100 | 24 |
| design my own plans | 25 | 16 | 32 | 12 | 11 | 13 | 11 | 23 | 28 | 28 | 25 | 20 | 7 | 22 | 24 | 32 | 24 | 25 | 11 | 45 | 19 | 26 | 33 | 28 | 24 | 100 |
| organize ideas into them | 26 | 15 | 26 | 21 | 19 | 22 | 11 | 23 | 34 | 28 | 36 | 34 | 9 | 24 | 34 | 32 | 35 | 42 | 30 | 32 | 40 | 43 | 37 | 36 | 34 | 33 |
| develop new ideas on the | 27 | 18 | 28 | 7 | 14 | 10 | 13 | 27 | 30 | 26 | 26 | 29 | 22 | 36 | 36 | 34 | 38 | 49 | 48 | 40 | 45 | 38 | 46 | 39 | 40 | 30 |
| make original contributi | 28 | -3 | 5 | -5 | 4 | 0 | 0 | 1 | 5 | 8 | 18 | 10 | 3 | 28 | 21 | 24 | 26 | 22 | 23 | 10 | 30 | 21 | 16 | 10 | 20 | 9 |
| solve problems by integr | 29 | 15 | 18 | -2 | 5 | 8 | 4 | 15 | 36 | 18 | 24 | 28 | 23 | 38 | 45 | 38 | 59 | 55 | 46 | 25 | 58 | 43 | 48 | 43 | 33 | 18 |
| organize ideas in new wa | 30 | 10 | 17 | 7 | 6 | 6 | 12 | 23 | 20 | 28 | 35 | 31 | 6 | 34 | 27 | 30 | 33 | 37 | 28 | 33 | 36 | 33 | 33 | 33 | 50 | 29 |
| logically defend | 31 | 17 | 27 | 6 | 7 | 5 | 3 | 23 | 31 | 19 | 25 | 22 | 5 | 30 | 29 | 30 | 30 | 31 | 27 | 34 | 38 | 36 | 40 | 28 | 30 | 38 |
| evaluate alternative sol | 32 | 8 | 18 | 3 | 5 | 6 | 1 | 13 | 22 | 21 | 28 | 26 | 5 | 38 | 36 | 37 | 39 | 40 | 35 | 22 | 41 | 39 | 35 | 37 | 39 | 29 |
| detect missing parts in | 33 | 9 | 17 | 4 | 10 | 1 | 9 | 22 | 20 | 18 | 17 | 28 | 22 | 26 | 25 | 23 | 29 | 44 | 40 | 19 | 35 | 33 | 30 | 32 | 28 | 17 |
| judge the logic of writt | 34 | 12 | 25 | 19 | 13 | 18 | 20 | 20 | 30 | 19 | 27 | 38 | 19 | 23 | 29 | 23 | 32 | 40 | 29 | 23 | 36 | 44 | 41 | 36 | 35 | 24 |
| identify the strengths a | 35 | 12 | 21 | 9 | 8 | 9 | 8 | 18 | 25 | 18 | 32 | 30 | 15 | 32 | 26 | 28 | 28 | 39 | 41 | 22 | 40 | 40 | 39 | 34 | 32 | 19 |
| identify bias in written | 36 | -7 | 10 | 2 | 8 | 2 | -1 | 9 | 11 | 15 | 23 | 14 | 5 | 29 | 27 | 31 | 31 | 32 | 23 | 14 | 32 | 26 | 32 | 27 | 26 | 8 |

| | | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| organize ideas into them | 26 | 100 | 38 | 27 | 39 | 38 | 37 | 35 | 23 | 33 | 43 | 20 |
| develop new ideas on the | 27 | 38 | 100 | 25 | 38 | 39 | 34 | 31 | 50 | 36 | 41 | 29 |
| make original contributi | 28 | 27 | 25 | 100 | 27 | 30 | 30 | 41 | 21 | 10 | 41 | 23 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| solve problems by integr | 29 | 39 | 38 | 27 | 100 | 27 | 37 | 43 | 32 | 34 | 28 | 27 |
| organize ideas in new wa | 30 | 38 | 39 | 30 | 27 | 100 | 35 | 42 | 33 | 31 | 38 | 29 |
| logically defend | 31 | 37 | 34 | 30 | 37 | 35 | 100 | 38 | 28 | 32 | 39 | 20 |
| evaluate alternative sol | 32 | 35 | 31 | 41 | 43 | 42 | 38 | 100 | 32 | 31 | 34 | 30 |
| detect missing parts in | 33 | 23 | 50 | 21 | 32 | 33 | 28 | 32 | 100 | 45 | 43 | 38 |
| judge the logic of writt | 34 | 33 | 36 | 10 | 34 | 31 | 32 | 31 | 45 | 100 | 48 | 35 |
| identify the strengths a | 35 | 43 | 41 | 41 | 28 | 38 | 39 | 34 | 43 | 48 | 100 | 44 |
| identify bias in written | 36 | 20 | 29 | 23 | 27 | 29 | 20 | 30 | 38 | 35 | 44 | 100 |

* The original coefficients were multiplied by 100 and rounded into integer numbers

Figure 1: Smallest Space Analysis (SSA) of the 36 Items Based on the Pearson Coefficients Matrix



## Legend:

1 remember an extensive number of new terms
2 recall a substantial number of new concepts
3 recall a lot of factual information
4 remember an extensive number of facts
5 recall a significant number of facts
6 remember complex facts
7 translate complicated ideas into everyday language
8 translate difficult concepts into my own words
8 interpret the meaning of new facts and terms
10 understand difficult ideas
11 translate a variety of technical terms into ordinary terms
12 interpret the meaning of complicated charts and graphs
13 demonstrate how theories are useful in real life
14 use theories to address practical questions
15 illustrate abstract ideas with concrete examples
16 use theoretical ideas to address practical problems
17 apply theories to new situations
18 apply theoretical principles in solving problems
19 identify organizing principles in my courses
20 identify the reasoning underlying theories
21 analyze complex interrelationships between concepts
22 identify assumptions underlying theories
23 identify the basic ideas in theories
24 illustrate how the different aspects of my discipline are related
25 design my own plans in completing assignments
26 organize ideas into themes
27 develop new ideas based on theories
28 make original contributions to classroom discussions
29 solve problems b integrating theories
30 organize ideas in new ways
31 logically defend a course of action
32 evaluate alternative solutions to problems
33 detect missing parts in arguments
34 judge the logic of written arguments
35 identify the strength and weakness of arguments
36 identify bias in written material

# Table 2: Six Pearson Correlation Matrices (A-F)

## A Knowledge Items

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 1 | 100 | 59 | 52 | 59 | 52 | 57 |
| 2 | 59 | 100 | 50 | 53 | 49 | 46 |
| 3 | 52 | 50 | 100 | 74 | 76 | 69 |
| 4 | 59 | 53 | 74 | 100 | 81 | 78 |
| 5 | 52 | 49 | 76 | 81 | 100 | 77 |
| 6 | 57 | 46 | 69 | 78 | 77 | 100 |

## B Comprehension Items

| | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|
| 7 | 100 | 49 | 33 | 39 | 53 | 16 |
| 8 | 49 | 100 | 32 | 33 | 54 | 16 |
| 9 | 33 | 32 | 100 | 32 | 45 | 12 |
| 10 | 39 | 33 | 32 | 100 | 42 | 22 |
| 11 | 53 | 54 | 45 | 42 | 100 | 19 |
| 12 | 16 | 16 | 12 | 22 | 19 | 100 |

## C Application Items

| | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|
| 13 | 100 | 51 | 41 | 42 | 48 | 43 |
| 14 | 51 | 100 | 37 | 49 | 46 | 37 |
| 15 | 41 | 37 | 100 | 48 | 44 | 32 |
| 16 | 42 | 49 | 48 | 100 | 60 | 41 |
| 17 | 48 | 46 | 44 | 60 | 100 | 51 |
| 18 | 43 | 37 | 32 | 41 | 51 | 100 |

## D Analysis Items

| | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|
| 19 | 100 | 25 | 32 | 34 | 29 | 19 |
| 20 | 25 | 100 | 39 | 53 | 48 | 32 |
| 21 | 32 | 39 | 100 | 48 | 37 | 35 |
| 22 | 34 | 53 | 48 | 100 | 51 | 42 |
| 23 | 29 | 48 | 37 | 51 | 100 | 31 |
| 24 | 19 | 32 | 35 | 42 | 31 | 100 |

## E Synthesis Items

| | 25 | 26 | 27 | 28 | 29 | 30 |
|---|---|---|---|---|---|---|
| 25 | 100 | 33 | 30 | 9 | 18 | 29 |
| 26 | 33 | 100 | 38 | 27 | 39 | 38 |
| 27 | 30 | 38 | 100 | 25 | 38 | 39 |
| 28 | 9 | 27 | 25 | 100 | 27 | 30 |
| 29 | 18 | 39 | 38 | 27 | 100 | 27 |
| 30 | 29 | 38 | 39 | 30 | 27 | 100 |

## F Evaluation Items

| | 31 | 32 | 33 | 34 | 35 | 36 |
|---|---|---|---|---|---|---|
| 31 | 100 | 38 | 28 | 32 | 39 | 20 |
| 32 | 38 | 100 | 32 | 31 | 34 | 30 |
| 33 | 28 | 32 | 100 | 45 | 43 | 38 |
| 34 | 32 | 31 | 45 | 100 | 48 | 35 |
| 35 | 39 | 34 | 43 | 48 | 100 | 44 |
| 36 | 20 | 30 | 38 | 35 | 44 | 100 |

* The original coefficients were multiplied by 100 and rounded into integer numbers

## Legend:

A
1 remember an extensive number of new terms
2 recall a substantial number of new concepts
3 recall a lot of factual information
4 remember an extensive number of facts
5 recall a significant number of facts
6 remember complex facts

B
7 translate complicated ideas into everyday language
8 translate difficult concepts into my own words
8 interpret the meaning of new facts and terms
10 understand difficult ideas
11 translate a variety of technical terms into ordinary terms
12 interpret the meaning of complicated charts and graphs

C
13 demonstrate how theories are useful in real life
14 use theories to address practical questions
15 illustrate abstract ideas with concrete examples
16 use theoretical ideas to address practical problems
17 apply theories to new situations
18 apply theoretical principles in solving problems

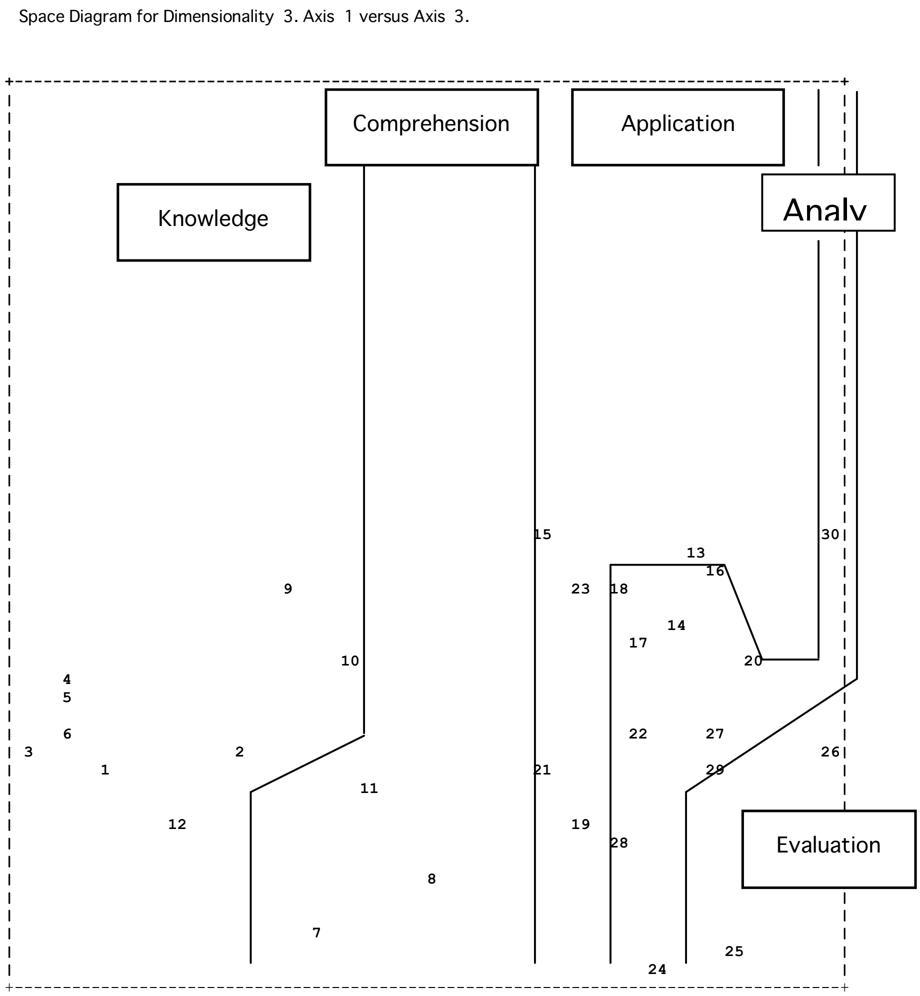
D
19 identify organizing principles in my courses
20 identify the reasoning underlying theories
21 analyze complex interrelationships between concepts
22 identify assumptions underlying theories
23 identify the basic ideas in theories
24 illustrate how the different aspects of my discipline are related

E
25 design my own plans in completing assignments
26 organize ideas into themes
27 develop new ideas based on theories
28 make original contributions to classroom discussions
29 solve problems b integrating theories
30 organize ideas in new ways

F
31 logically defend a course of action
32 evaluate alternative solutions to problems
33 detect missing parts in arguments
34 judge the logic of written arguments
35 identify the strength and weakness of arguments
36 identify bias in written material

Figure 2: Smallest Space Analysis (SSA) of the 30 Items Based on the Pearson

Coefficients Matrix



## Legend:

1 remember an extensive number of new terms
2 recall a substantial number of new concepts
3 recall a lot of factual information
4 remember an extensive number of facts
5 recall a significant number of facts
6 remember complex facts
7 translate complicated ideas into everyday language
8 translate difficult concepts into my own words
8 interpret the meaning of new facts and terms
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19 identify organizing principles in my courses
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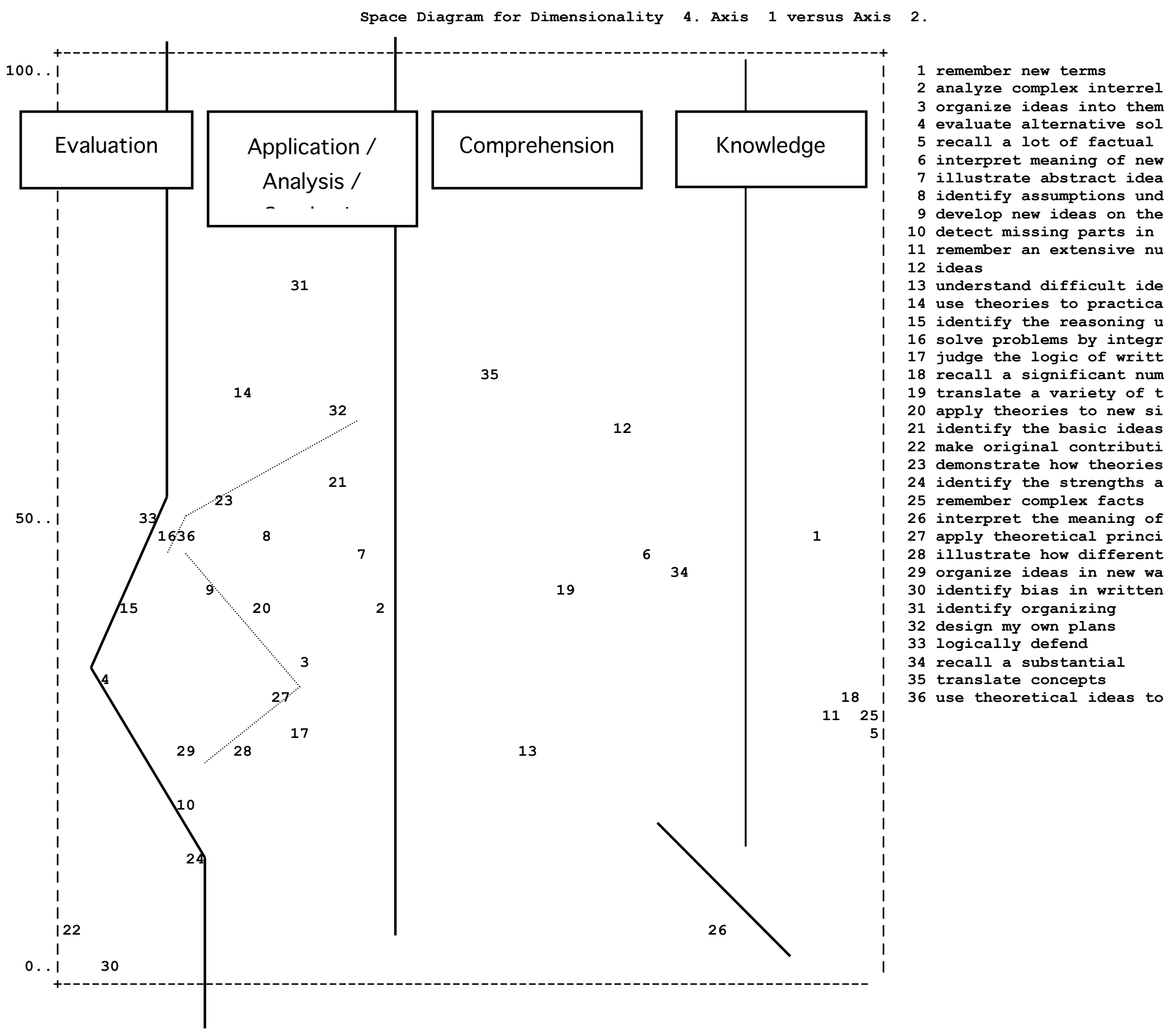
22 identify assumptions underlying theories
23 identify the basic ideas in theories
24 illustrate how the different aspects of my discipline are related
25 logically defend a course of action
26 evaluate alternative solutions to problems
27 detect missing parts in arguments
28 judge the logic of written arguments
29 identify the strength and weakness of arguments
30 identify bias in written material

## Figure 1: Cognitive Map of the 36 Items Based on the Pearson Coefficients Matrix



## Legend:

1 remember an extensive number of new terms
2 recall a substantial number of new concepts
3 recall a lot of factual information
4 remember an extensive number of facts
5 recall a significant number of facts
6 remember complex facts
7 translate complicated ideas into everyday language
8 translate difficult concepts into my own words
8 interpret the meaning of new facts and terms
10 understand difficult ideas
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31 logically defend a course of action
32 evaluate alternative solutions to problems
33 detect missing parts in arguments
34 judge the logic of written arguments
35 identify the strength and weakness of arguments
36 identify bias in written material