An Analysis of Course Evaluation Questionnaire by Machine Learning

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Abstract. Course evaluation by questionnaire is the most popular assessment tool for the faculty development of University in Japan. However, many universities do not fully utilize the result of these questionnaires. Usually, traditional statistical tools such as average or standard deviation are used to analyze the questionnaires. Recently, more advanced statistical tools are available and many of them come from the field of machine learning. We thus tried to analyze the course evaluation questionnaire using the advanced statistical tools. In this paper, the questionnaires obtained at National Defense Academy of Japan were analyzed. This questionnaire has been conducted for 10 years history to more than thousand cadets, but the questionnaires have not been analyzed up to the present. This study analyzed and evaluated the reliability of the class questionnaire through the statistical analysis. As a result, potential factors and their relationship were discovered in a questionnaire using Structural Equation Modeling.

Keywords: Course evaluation, Questionnaire analysis, Structural Equation Modeling, Machine learning
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INTRODUCTION

In almost all of the university in Japan, faculty development activity has been compulsory since 1997 [1]. In response to the report from Japanese Education Ministry, many universities started their faculty development activities. These activities aim to improve the teaching ability of the staff in university.

Course evaluation by questionnaire is one of the most popular activities in Japanese university. However, there are very few cases in which the results of the questionnaires are properly utilized [2]. It is because long-lasting organizational effort to review contents of questions, setting of questions, and causal relations between factors behind questions are carefully considered in order to utilize the result of questionnaires [3].

National Defense Academy of Japan (NDA) has been conducting its course evaluation questionnaires for more than 10 years and gross number of the respondents is over 250,000 cadets. From the viewpoint of data analysis, the questionnaires in NDA are expected to be the source of promising results. Therefore, we analyzed them using advanced statistical tools beyond the traditional questionnaire analysis.

METHOD OF ANALYSIS

In this study, we adopt Structural Equation Modeling (SEM) [4]. SEM is a very general statistical modeling technique and it is a combination of factor analysis [5] and regression [5]. SEM is often visualized by graphical path diagram. The statistical model is usually represented in a set of matrix equations.

The procedure of SEM is performed following steps:

(1) Model specification: There are two types of models in SEM – the structural model and the measurement model. The former is the model for the potential causal relationship between endogenous and exogenous variables. Path diagrams are used in this part. The latter is the model for the relations between latent variables and their indicators. Factor analysis is used in this part.

(2) Parameter estimation: The actual and estimated covariance matrices that represent the relationship between observed variables are compared for parameter estimation. Maximum likelihood estimation, or least squares are often used to fit criterion.

(3) Statistical test: In order to determine how well the estimated model fits the data, statistical test is done. Chi-squared test and Akaike information criterion [5] are commonly used.

(4) Model modification: The relations between variables are modified in order to improve the fitness. This modification is a change to the theory. Therefore, the modification must make sense in terms of the theory being tested.

QUESTIONNAIRES IN NDA

The questionnaires for course evaluation in NDA began 2004. It is conducted online and the cadets of NDA answer the questionnaires once in a semester (but, twice a semester from 2010). A questionnaire consists of seven questions:

Q1: "Setting of goals". Did the lecturer of the class show the goals of the lecture?
     5: Strongly Agree, 4: Agree, 3: Neutral, 2: Disagree, 1: Strongly Disagree

Q2: "Way of teaching". Did the lecturer check your understanding? Did the lecturer communicate well?
     5: Strongly Agree, 4: Agree, 3: Neutral, 2: Disagree, 1: Strongly Disagree

Q3: "Technique of education". Did the lecturer use the teaching material appropriately and effectively?
     5: Strongly Agree, 4: Agree, 3: Neutral, 2: Disagree, 1: Strongly Disagree

Q4: "Attitude of lecturer". Did the lecturer bring the enthusiasm in the class?
     5: Strongly Agree, 4: Agree, 3: Neutral, 2: Disagree, 1: Strongly Disagree

Q5: "Degree of attainment". Did you gain much from this lecture?
     5: Strongly Agree, 4: Agree, 3: Neutral, 2: Disagree, 1: Strongly Disagree

Q6: "Degree of your effort". Did you prepare well? Did you study hard?
     5: Strongly Agree, 4: Agree, 3: Neutral, 2: Disagree, 1: Strongly Disagree

Q7: "Others".
     Free description.

In this study, we use the first six questions for analysis.

ANALYISIS OF COURSE EVALUATION QUESTIONNAIRES IN NDA

Preliminary Results

We investigate the scores of each question in the questionnaires in advance of SEM. Figure 1 shows a contour plot of the correlation between questions in the questionnaire. The correlation is greater than 0.8 almost everywhere. Figure 2 shows the result of hierarchical clustering of the questions in the questionnaire. Ward's method is used as a criterion of the clustering [5]. We can see three clusters: Cluster 1: Q6, Cluster 2: Q2 and Q3, and Cluster 3: Q4, Q1, and Q5. We utilized this information for the model specification of SEM.
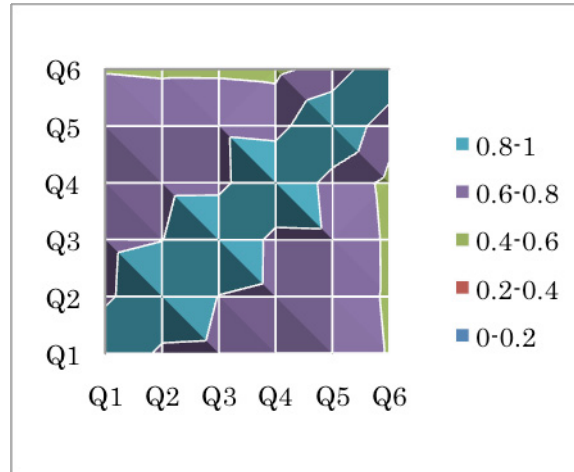
FIGURE 1. Contour Plot of the coefficient of correlation between questions in the questionnaire.
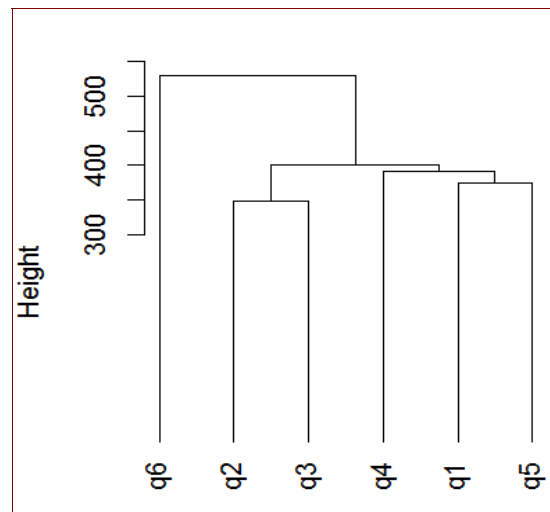

FIGURE 2. Hierarchical clustering of questions in the questionnaire.

The Results of SEM

Figure 3 shows the three highly fitted models derived by Structural Equation Model. Table 1 shows the fitness of each model from several criteria. Model A is the most fitted one. There are two potential factors among questions. One can be interpreted as "effort by cadets", and the other can be interpreted as "effort by lecturers". As to the factor of the effort of students, Q5 has stronger influence than Q6. As to the factor of the effort of lectures, Q2 and Q3 have stronger influence than Q1 and Q4. In Model B, potential factor can be interpreted as "effort by lectures". In Model C, potential factors are interpreted as "teaching technique" and "explicitness of the lecture".
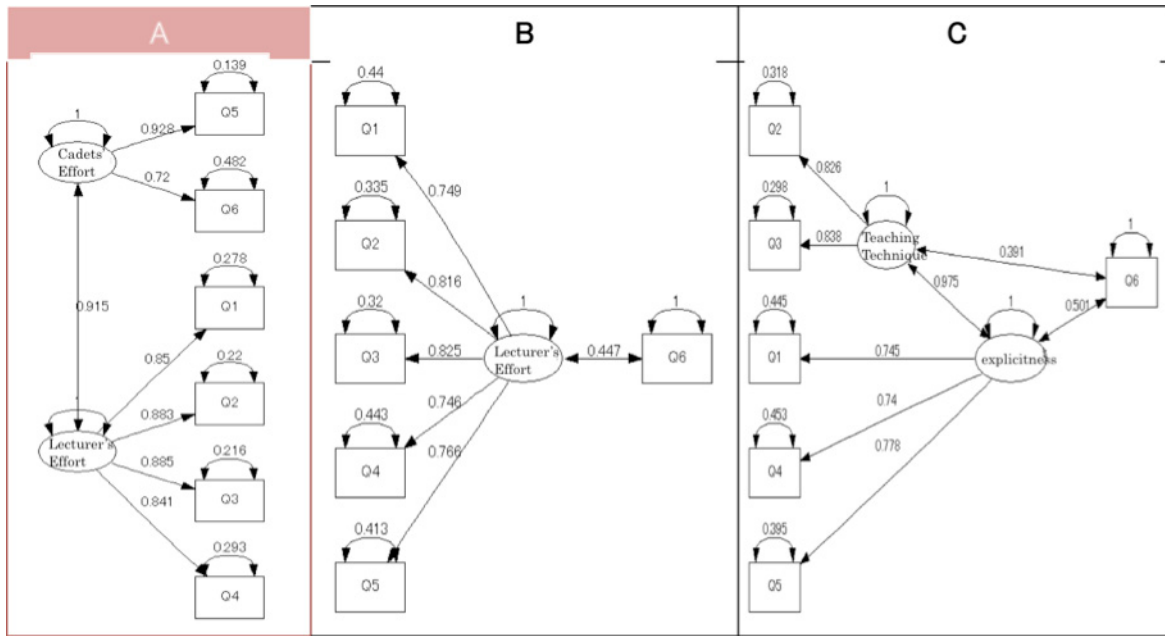
FIGURE 3. SEM analysis of the course evaluation questionnaires in NDA. Boxes represent the variables and circles represent potential factors.

TABLE 1. Fitness of three models in FIGURE 3. (AIC: Akaike Information Criterion, BIC: Bayesian Information Criterion)

Model	Chi-Squared Test	AIC	BIC
Model A	0.999	26.903	-30.392
Model B	0.952	30.130	-25.253
Model C	0.919	27.882	-31.325

CONCLUSION

We analyzed 10 years record of course evaluation questionnaires of National Defense Academy of Japan. With Structural Equation Modeling, we revealed two potential factors behind the questionnaire and the effects of the factors on each question. With these results, we can improve not only our teaching skills, but also contents of questions. As future works, we are planning to analyze the combination of the questionnaires with other data such as academic result or environment factors such as time and place of the class.

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