

EVALUATION OF COMPUTER ETHICS: CONFIRMATORY FACTOR MODELS USING PROC CALIS

MASLIN MASROM

¹College of Science and Technology, Universiti Teknologi Malaysia
Jalan Semarak 54100 Kuala Lumpur
maslin@citycampus.utm.my

ZURAINI ISMAIL²

²College of Science and Technology, Universiti Teknologi Malaysia
Jalan Semarak 54100 Kuala Lumpur
zurainisma@citycampus.utm.my

The computer is considered one of the most essential technological advances and has become an everyday tool. Many tertiary institutions have become heavily dependent on computers, Internet and information systems for educational purpose. Computers and the Internet also represent many people, organizations, and governments. However, at the same time they raise some ethical issues such as unauthorized access and use of computer systems, software piracy and information privacy. This study proposes the employment of computer use and computer security concepts for investigating students' ethical conduct related to computer ethics. Specifically, an ethical computer awareness (ECA) construct concerning computer use and security is developed and validated. The process of evaluating a measurement instrument for reliability and investigating the factor structure are discussed using the scale of ethical computer awareness (SECA). SAS[®] procedures served to provide an indication of the internal consistency, that is, reliability with PROC CORR, to explore the factor structure with exploratory factor analysis using PROC FACTOR, and to verify the factor structure with confirmatory factor analysis using PROC CALIS of the measurement instrument. The ECA construct developed from the study could be useful to research a wide range of computer ethics in the future.

Keywords: SAS PROC CORR, SAS PROC FACTOR, SAS PROC CALIS, Confirmatory Factor Analysis.

1. Introduction

In today's world computers are one of the core technologies, and they have become central to the operations of industry, military, education, research and many others. One factor behind the rise of computer ethics is the lingering doubt that computer professionals may be not prepared to deal effectively with the ethical issues that arise in the workplace (Maner, 1996). In other words, the positive morals and values need to influence the character of the computer science professionals as they make decisions. The study of computer ethics is an essential aspect in the education of future professionals. In this context, the teaching of computer ethics in the preparation of computer professionals, and the education of the general computer user, is an area of increasing importance and interest (Turner & Roberts, 2001). Dolado (2000) asserted that the general feeling is that moral principles and ethical behaviour should be taught whenever a profession wants to be established.

The importance of computer ethics education for the computing professional was recognized a decade ago, and in this respect, the authors agree with the following excerpt (Martin and Yale-Weltz, 1999) that summarizes the ACM / IEEE Joint Curriculum Taskforce's position regarding computer ethics in education:

"Undergraduate need to understand the basic cultural, social, legal, and ethical issues inherent in the discipline of computing. They should understand where the discipline has been, where it is, and where it is heading. They should understand their individual roles in this process, as well as appreciate the philosophical questions, technical problems, and aesthetic values that play an

important part in the development of the discipline... Students also need to develop the ability to ask serious questions about social impact and to evaluate proposed answers to these questions."

This study proposes the employment of computer use and computer security concepts for investigating students' ethical conduct related to computer ethics. Specifically, an ethical computer awareness (ECA) construct concerning computer use and security is developed and validated. In the following sections, the process of evaluating a measurement instrument for reliability and investigating the factor structure are discussed using the scale of ethical computer awareness (SECA). SAS[®] procedures served to provide an indication of the internal consistency, that is, reliability with PROC CORR, to explore the factor structure with exploratory factor analysis using PROC FACTOR, and to verify the factor structure with confirmatory factor analysis using PROC CALIS of the measurement instrument.

2. Reliability And Exploratory Factor Analysis

According to Suhr (2003), reliability is a function of properties of the underlying construct being measured, the test itself, the groups being assessed, the testing environment, and the purpose of assessment. Assessing the scale reliability of the factors with coefficient alpha should be the first time we do when we complete the survey. In this context, the PROC CORR allows users to know how to optimise the Cronbach's Alpha when deleting awkward variables. The results of PROC CORR then can be used to perform an item analysis, thereby improving the scale reliability. On the other hand, exploratory factor analysis (EFA) is appropriate when we want to identify the number of constructs and the underlying factor structure (Suhr, 2003). The use of factor analysis assumes that each of the observed variables being analyzed are measured on an interval or ratio scale. In order to run the EFA, PROC FACTOR in SAS can be used.

3. Confirmatory Factory Analysis – Proc Calis

To carry out a confirmatory factor analysis (CFA) in SAS, we need to use PROC CALIS (Covariance Analysis of Linear Structural Equations). Its' procedure provides the number of observations, variables, estimated parameters, and information (related to model specification). It tests the appropriateness of structural equation models using covariance structural analysis (Suhr, 2006). Confirmatory factor analysis (CFA) is a special case of structural equation modeling (SEM) which was designed to specify linear relations.

4. Statistical Analysis

The reliability, exploratory and confirmatory factor analysis of the study are presented below.

Subjects

Subjects were 142 male and 103 female students at College of Science and Technology, Universiti Teknologi Malaysia, Kuala Lumpur. The mean age of the subjects was 25.2 (S.D. = 1.1).

Assessing Coefficient Alpha with PROC CORR: Reliability (2-factors)

Cronbach alpha for the computer ethical awareness scale was calculated with PROC CORR using the factor structure suggested by Namlu and Odabasi (2007). Reliability of the 2 factor structure ranged from 0.79 to 0.85 with a mean of 0.82. The SAS code below calculates alpha for the "Computer Use" factor.

SAS Code - Computer Use

```

PROC CORR DATA=WORK.compethicexcel
  ALPHA
  PEARSON
  VARDEF=DF
  OUT=DATA1;
  VAR ethic1 ethic2 ethic3 ethic4 ethic5 ethic6 ethic7
  ethic8;
RUN;
    
```

Table 1 lists the 2 factors, item included in each factor, and factor alphas for the study sample (n=245).

Table 1: Scale of Computer Ethical Awareness – Factor Structure and Reliability

Factor	Items	Alpha
Computer Use	ethic1, ethic2, ethic3, ethic4, ethic5, ethic6, ethic7, ethic8	0.853
Computer Security	csec6, csec7, csec8, csec11, csec12, csec13	0.791
Total Scale	ethic1, ethic2, ethic3, ethic4, ethic5, ethic6, ethic7, ethic8, csec6, csec7, csec8, csec11, csec12, csec13	0.755

Table 2 illustrates output from SAS’s PROC CORR procedure (standardized variables not shown). Alpha for the “Computer Use” factor is 0.853. The results indicate that if ethic8 were deleted, the alpha would increase to 0.858 for the remaining 7 items.

Table 2: SECA Computer Use Factor Reliability

```

The CORR Procedure
8 variables      ethic1, ethic2, ethic3, ethic4, ethic5, ethic6,
ethic7, ethic8
Cronbach Coefficient Alpha
Variables                Alpha
Raw                      0.852577
Standardized            0.857667

Raw Variables
Deleted Variable      Correlation With Total      Alpha
ethic1                0.570832                0.838156
ethic2                0.584419                0.835892
ethic3                0.733443                0.817878
ethic4                0.711921                0.820922
ethic5                0.627352                0.831608
ethic6                0.492543                0.850110
ethic7                0.677943                0.824431
ethic8                0.406605                0.858143
    
```

Assessing EFA Model with PROC FACTOR

SAS Code: Exploratory factor Analysis

```

PROC FACTOR DATA=WORK.compethicexcel
    METHOD=ML
    VARDEF=DF
    MINEIGEN=1
    PRIORS=SMC
    HEYWOOD
    NFACT=2
    ROTATE=VARIMAX
    REORDER
    NORM=KAISER
    SCREE SCORE
    ROUND
    FLAG=0.4
    OUT=DATA2;
    VAR    ethic1 ethic2 ethic3 ethic4 ethic5 ethic6 ethic7
          ethic8 csec6 csec7 csec8 csec11 csec12 csec13;
    RUN:
    
```

Two factors are retained, cumulative variance is 0.9507. Preliminary eigenvalues are 7.50208438 and 4.53284884. Each factor explains 59% and 95% of the variance.

```

The FACTOR Procedure
Initial Factor Method: Maximum Likelihood
Preliminary Eigenvalues: Total = 12.6589888   Average = 0.90421349
    
```

	Eigenvalue	Difference	Proportion	Cumulative
1	7.50208438	2.96923554	0.5926	0.5926
2	4.53284884	3.17229279	0.3581	0.9507
3	1.36055605	0.70691831	0.1075	1.0582
4	0.65363775	0.30590407	0.0516	1.1098
5	0.34773368	0.14308913	0.0275	1.1373
6	0.20464454	0.11510383	0.0162	1.1534
7	0.08954072	0.19538224	0.0071	1.1605
8	-.10584152	0.07971045	-0.0084	1.1522
9	-.18555197	0.02032791	-0.0147	1.1375
10	-.20587989	0.06886059	-0.0163	1.1212
11	-.27474047	0.08786617	-0.0217	1.0995
12	-.36260664	0.07224981	-0.0286	1.0709
13	-.43485645	0.02772372	-0.0344	1.0365
14	-.46258017		-0.0365	1.0000

2 factors will be retained by the NFACTOR criterion.

Factor loadings illustrate correlations between items and factors.

Rotated Factor Pattern		
	Factor1	Factor2
ethic1	64 *	-8
ethic2	64 *	-7
ethic3	81 *	-6
ethic4	79 *	-2
ethic5	68 *	-7
ethic6	54 *	10
ethic7	72 *	6
ethic8	44 *	-1
csec6	-13	55 *
csec7	-2	55 *
csec8	1	52 *
csec11	-3	73 *
csec12	4	77 *
csec13	4	61 *

Assessing CFA Model with PROC CALIS

Figure 1 illustrates the confirmatory factor model for computer ethics.

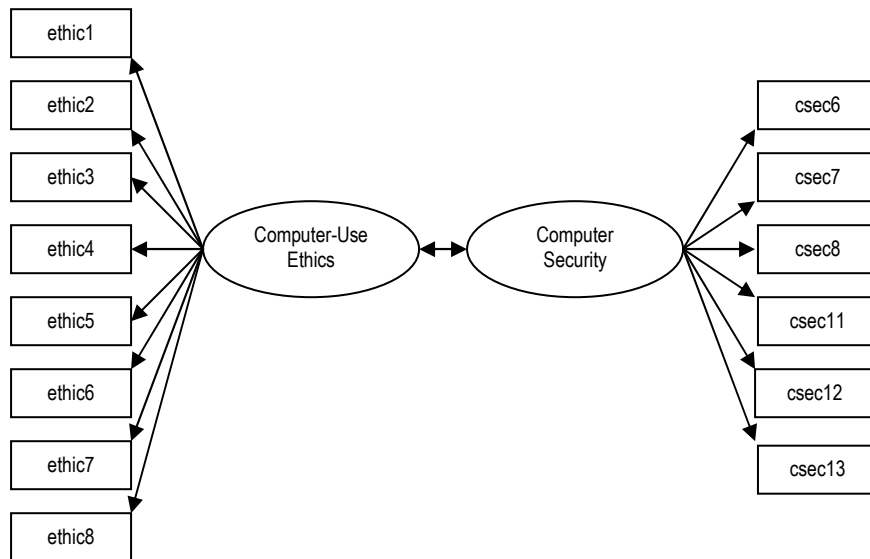


Figure 1. CFA Model for Computer Ethics

Confirmatory factor analysis model was run with PROC CALIS using the following SAS code in order to test the underlying factor structure.

```

PROC CALIS DATA=WORK.compethicexcel COVARIANCE CORR RESIDUAL
MODIFICATION;
LINEQS
  ethic1 = Lethic1F1 F1 + ER1,
  ethic3 = Lethic3F1 F1 + ER2,
  ethic4 = Lethic4F1 F1 + ER3,
  ethic5 = Lethic5F1 F1 + ER4,
  ethic8 = Lethic8F1 F1 + ER5,
  csec11 = Lcsec11F2 F2 + ER6,
  csec12 = Lcsec12F2 F2 + ER7,
  csec13 = Lcsec13F2 F2 + ER8;
STD
  F1=1,
  F2=1,
  ER1-ER8=VARER1-VARER8;
COV
  F1 F2 = CF1F2;
VAR ethic1 ethic3 ethic4 ethic5 ethic8 csec11 csec12 csec13;
RUN;

```

Fit Statistics

PROC CALIS produces several different measures of model fit. These measures of fit generally fall into 3 categories. First, the chi-square (χ^2) goodness-of-fit statistic assesses the magnitude of discrepancy between the sample and fitted covariance matrices. The second category consists of absolute fit indices, which assesses how well an *a priori* model reproduces the sample data. PROC CALIS produces estimates of several absolute fit indices, including the goodness of fit index (GFI) and the root mean squared error of approximation (RMSEA). The third general category of fit index contains incremental fit indices, which measure the proportionate improvement in fit by comparing a target model with a more restricted, nested baseline model. Incremental fit indices produced by PROC CALIS include Bentler's Comparative Fit Index (CFI), Bentler and Bonett's Non-Normed Index (NNI),

Bollen's Normed Rho1, and Bollen's Delta2. Generally, it is desirable to consider a combination of fit indices from all three of these categories when evaluating overall model fit.

The process for assessing fit between model and data as suggested by Hatcher (1994) begins by reviewing overall goodness of fit indices (e.g. chi-square test, the CFI, and the NFI), and then proceeds to indices that provide a more detailed assessment of fit (significance tests for factor loadings, R^2 values, normalized residuals, and modification indices). As shown in Table 3, the chi-square probability revealed an unacceptable model fit (chi-square=30.4738, df = 19, p=0.0461) since the acceptable model fit is determined by a chi-square value close to zero and a probability value (p) greater than 0.05. RMSEA indicates the amount of unexplained variance or residual. In this study RMSEA value (0.0497) is smaller than the 0.06, CFI (0.9815), NNI (0.9728), and NFI (0.9531) values meet the criteria (0.90 or larger) for acceptable model fit (Hu & Bentler, 1999). The CFA analysis has confirmed the factor structure. In other words, results indicated good model fit.

Table 3 . Goodness of Fit Indices

The CALIS Procedure	
Covariance Structure Analysis: Maximum Likelihood Estimation	
Fit Function	
Chi-Square	30.4738
Chi-Square DF	19
Pr > Chi-Square	0.0461
RMSEA Estimate	0.0497
Bentler's Comparative Fit Index (CFI)	0.9815
Bentler & Bonett's (1980) Non-normed Index (NNI)	0.9728
Bentler & Bonett's (1980) NFI	0.9531

Parameter estimates for the confirmatory factor models are significant at the 0.01 level (the t value exceeds 2.56).

5. Conclusion

Confirmatory factor analysis is generally the preferred method for establishing the convergent and discriminant validity for a confirmatory factor model. It depends on several statistical test to determine the adequacy of model fit to the data. With the exploratory factor analysis, we are unsure the number of factors being measured, and use the results of the analysis to help solve the number-of-factors problem. But, with confirmatory factor analysis we must have a good idea regarding the number of factors being assessed and knowledge which measured variables load on which factors. This study reveals that PROC CALIS proved can be used to perform the statistical analyses for the development and analysis of measurement items, and also provide more information regarding the items

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