International Research Journal of Natural and Applied Sciences
ISSN: (2349-4077)
Impact Factor- 5.46, Volume 4, Issue 10, October 2017
Website- www.aarf.asia, **Email** : editor@aarf.asia, editoraarf@gmail.com

THE CONSTRUCTION AND EVALUATION OF THE COMPETENCY INVENTORY OF NURSING STUDENTS IN TAIWAN

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ABSTRACT

This study was to examine the psychometric properties of the Competency Inventory of Nursing Students (CINS) for 1103 baccalaureate nursing students from a university in northern Taiwan. The respondents were randomly assigned either to principal components analysis with varimax rotation or confirmatory factor analysis. Principal components analysis revealed eight components of core competencies that were named "Ethics and caring", "Knowledge and skills", "Accountability", "Life-long learning", "Global view", "Communication and teamwork", "Basic biomedical science", and "Critical thinking and reasoning". The final model of confirmatory factor analysis was converged to an acceptable fit. Six indicators have correlated measurement errors. In conclusion, the CINS

could be used to assess the core competencies of undergraduate nursing students.

KEYWORDS -nursing core competency, nursing education, exploratory factor analysis, principal components analysis, confirmatory factor analysis

INTRODUCTION

By employing the theory of outcome-based education, the most important value of nursing education is to train 'nursing personnel to be trusted by patients and their families' (Chin, 2010; Hsu, 2014). Nursing core competencies are considered to be the most critical learning outcomes for nursing students, and several researchers have applied diverse teaching strategies aimed at improving students' nursing core competencies (Fan, Wang, Chao, Jane, & Hsu, 2015; Lavoie et al., 2017; Pai, 2015).

Different organizations and researchers hold different opinions about nursing core competencies. According to the International Council of Nurses (2003), nursing personnel should possess five competencies when entering the nursing industry, including professional, ethical and legal practice, care provision, management, and professional development competencies. The Taiwan Nursing Accreditation Council (TNAC) instead recommends that core competencies of the basic nursing education should include three major aspects, namely professional skills, professional humanity, and self-improvement, as well as the following eight core competencies: critical thinking and reasoning, general clinical skills, basic biomedical science, communication and team work capability, caring, ethics, accountability, and life-long learning (Yu, 2010).

To date, a number of reliable and valid nursing competency inventories have been developed (Hsu & Hsieh, 2009; Safadi, Jaradeh, Bandak, &Froelicher, 2010), and yet the selection of appropriate inventories needs to be fully reflect the individual university's philosophy, aims of education, and objectives of course design (Perng, Lai, Hwang, & Tsai, 2013; Lai, 2013; Chung, & Hsu, 2007). Considering the uniqueness of specific nursing

program in our university, the available scales cannot fit the teaching aims and motto of the school, thus, the purpose of this study was to construct a Competency Inventory of Nursing Students (CINS) and examine its psychometric properties in accordance with the teaching aims and motto of the school from a technology university in northern Taiwan.

METHODS

Study Process

The study consisted of two parts: first, to explore the core nursing competencies that nursing students should possess, as determined in nursing teachers' focus group discussions, and to use them as a reference for the construction of the competency inventory; second, to analyze the reliability and validity of the constructed inventory using a quantitative approach.

Part One: Development of Inventory Items

The core nursing competency scales established this study were largely based on the eight major nursing core competencies developed by the TNAC in Taiwan. After 12 rounds of focus group discussions, 10 core competencies were ultimately established in accordance with the school motto and teaching aims. A total of nine teachers were enrolled in the nursing core competency scale set-up team. The 10 competencies, namely "Basic biomedical science", "Knowledge and skills", "Critical thinking and reasoning", "Communication and teamwork", "Respect and caring", "Ethics", "Diligence and hardworking", "Nursing identity and dedication", "Life-long learning" and "Global view", were then subdivided into 49 core competency indicators, which were used to generate the questionnaire.

Part Two: Reliability and Validity Testing of the Inventory

Internal consistency was applied in the reliability test to calculate Cronbach's α, and content validity and construct validity were used to determine the validity of the competency inventory.

Design

A cross-sectional survey design was used.

Participants

A total of 1103 baccalaureate nursing students from a university in northern Taiwan were recruited by a purposive sampling and the study was conducted from Apr 1, 2015 to Jul 20, 2015. Out of 1225 questionnaires sent out, 1103 were completed, and 22 were returned only partially completed; therefore, the effective response rate was 90%.

Instruments

The Competency Inventory of Nursing Students (CINS; 49 items) was developed based on the eight core competencies stipulated by the TNAC. We used a 5-level Likert scale: 1 (not competent at all), 2 (inadequate), 3 (average), 4 (good), 5 (excellent). The possible score range was thus 49-245, where a high score represents a high level of competency. Based on a pilot study with 59 nursing students in a four-year nursing bachelor degree program, Cronbach's α for internal consistency of the CINS is 0.97, and the correlation coefficient of test-retest reliability is 0.75.

Ethical considerations

This study was approved by the Ethics Committee of the Institutional Review Board of the Chang Gung Medical Foundation, Taoyuan, Taiwan. Participants' consent to take part in the study was implied by completion of the questionnaire.

Data analysis

Content validity was first tested on the original inventory, which consisted of 49 items. Excluding the nine teachers who were earlier involved in the core competency scale set-up, a total of eight teachers (one each from the different nursing specialties) were invited

to assess the importance, correctness, suitability, and semantic simplicity of the questionnaire. The scoring scale applied the following 4-point Likert scale: 1 point (not suitable), 2 points (major revision required), 3 points (minor revision required), 4 points (suitable). Content validity index (CVI) was then calculated by dividing the number of items rated 4 points by the experts by the total item number. The CVI of the inventory was 0.95, which fulfilled the standard proposed by Waltz et. al (1991), i.e., that the CVI should be equal to or above 0.8 (Waltz, Strickland, & Lenz, 1991).

This study collected 1103 cases and generated a first data set (n_1 = 569) as a calibration sample for exploratory factor analysis (EFA), and a second data set (n_2 = 534) as a validation sample for confirmatory factor analysis (CFA) by random assigned. Data were analyzed using SPSS 18.0 and Amos 18.0 statistical software.

In the construct validity analysis, n_1 was used for EFA. Bartlett's Sphericity Test and Kiaiser-Meyer-Olkin measure of sampling adequacy (KMO) were applied to determine the relevance in factor analysis. Principal component analysis (PCA) is amongst the oldest of the multivariate statistical methods of data reduction. Therefore, PCA and varimax rotation analysis were conducted.

Thereafter, n_2 was used in CFA to evaluate the model fit. Amos 18.0 was used for Structural Equation Model (SEM) analysis, and the Maximum Likelihood (ML) method was used to estimate model indices. The model chi-square (χ^2), chi-square difference tests ($\chi^{2/df}$), goodness-of-fit index (GFI), adjusted goodness-of-fit index (AGFI), standardized root mean square residual (SRMR), root mean square error of approximation (RMSEA), normed fit index (NFI), non-normed fit index (NNFI), incremental fit index (IFI), comparative fit index (CFI), parsimony normed fit index (PNFI), and parsimony comparative fit index (PCFI) were used to evaluate the model fit.

RESULTS

Demographic data

The respondents consisted of 1034 female (93.7%) and 69 male (6.3%) students (Table 1) and 53% were enrolled in a four-year nursing bachelor degree program, whereas 46.9% were enrolled in a two-year nursing bachelor degree program. Respondents' ages ranged from 18–29 years (mean = 21.05, SD = 1.05).

Principal component analysis

The PCA varimax rotation using list-wise deletion revealed eight factors from n_1 (loading > 0.40, deleting item 19: "familiar with medical and nursing related paperwork"). The KMO measure of sampling adequacy was 0.96 (i.e., > 0.6). Bartlett's test was statistically significant, with $\chi^2 = 21605.92$ and $p < 0.001$, indicating that the variables were highly correlated. This shows evidence for common factors in the CINS, and provides a reasonable basis for EFA. The eight common factors were "Ethics and caring", "Knowledge and skills", "Accountability", "Life-long learning", "Global view", "Communication and teamwork", "Basic biomedical science", and "Critical thinking and reasoning". The final scale contains 48 items, and the EFA results are shown in Table 2. The eight factors explain 69.34% of the variance. The Cronbach's α value was 0.97 for the total scale; for all factors, Cronbach's α coefficient ranged from 0.84–0.93.

Confirmatory factor analysis

The ML method was applied using AMOS 18.0 to determine the construct validity of the inventory. Testing the overall fit of the initial model resulted in indices that suggested a poor fit, where $\chi^{2/df} = 3.653 > 3$, GFI = 0.746 < 0.90, and AGFI = 0.717 < 0.90. The relative fit indices, including NFI, NNFI, and IFI also suggested likewise. However, the SRMR and RMSEA indices were 0.063 and 0.071 respectively, suggesting that the model might work with some modifications. In cases where a good fit between model and data cannot be achieved, researchers used the Modification Index (MI) for model modification.

We carried out a total of six modifications by releasing the residuals and variance parameters of observed variables, including "item 24 ↔ item 25", "item 31 ↔ item 33", "item 39 ↔ item 40", "item 28 ↔ item 29", "item 26 ↔ item 27", and "item 30 ↔ item 31". After six modifications, the chi-square value of the initial hypothetical model changed from 2781.15 (df = 1046) to 3842.94 (df = 1052), a substantial decrease of 1061.79. Table 3 shows the goodness-of-fit test results of the overall model after modification by release of the aforementioned parameters.

Prior to the overall fit of the model was tested, offending estimates were examined to evaluate whether any acceptable ranges were exceeded, e.g., the presence of negative error variance, standardized coefficients above 1, standard errors that were too high, and statistically insignificant error variances. The results indicate that the error variances all fell between 0.046–0.311; none showed negative values, and all were statistically significant ($p< 0.001$). Furthermore, the standard errors ranged from 0.005–0.020, none of which were too high, and the standardized coefficients ranged from 0.660–0.955, i.e., there were no abnormal values exceeding 1. These results indicated that there were no offending estimates in the overall model estimation, and that evaluation of the fit indices may commence. We then tested the goodness-of-fit of the model as shown in Table 3, $\chi^{2/df} = 2.659 < 3$, SRMR = 0.061, RMSEA = 0.056, NNFI = 0.916, IFI = 0.922, and CFI = 0.922, indicating a fairly good fit (Figure 1).

DISCUSSION

Findings from PCA indicated that the CINS had eight factors, namely "Ethics and caring", "Knowledge and skills", "Accountability", "Life-long learning", "Global view", "Communication and teamwork", "Basic biomedical science", and "Critical thinking and reasoning". This eight-factor structure was confirmed via CFA, and the eight factors explain 69.34% of the variance. The Cronbach's α coefficients ranged from 0.84–0.93, which met

the good standard where factor loading is above 0.4, the total variance explained is above 60%, and Cronbach's α coefficient is above 0.70 (Nunnally, 1978; Wu, 2009). According to the above results, it appeared that the CINS had good construct validity for further CFA.

Multiple fit indices approved that the eight-factor model developed in this study had a good fit. The initial model of the CINS failed to approve to be good fit; then a new hypothetical model was generated, and the goodness-of-fit indices improved. All statistically significant parameters indicated that 48 items were representative of the construct of core competencies of nursing students, but had several associations with six measurement errors. In this study, SRMR, RMSEA, NNFI, IFI, and CFI were 0.061, 0.056, 0.916, 0.922, and 0.922 respectively, which met the standards recommended by experts; i.e., SRMR and RMSEA should be below 0.08, while CFI and NNFI should be above 0.90 (Hu &Bentler, 1998). Our study also used the GFI and AGFI indices to investigate the explanatory power of the model. In terms of investigating the explanatory power of the model, GFI and AGFI in this study were 0.820 and 0.800 respectively, i.e., lower than the recommended standard value of 0.90; however, previous studies have proposed a lowering of the standard to 0.80 in cases where more estimate indices suggest a good fit for the model (MacCallum&Hong, 1997; Hwang, 2007). Altogether, the overall goodness-of-fit indices of CINS showed acceptable fit of the model.

The initial 10 core competencies developed in the school were reduced to eight core competencies in the final model. The major differences were that "Respect and care" and "Ethics" were merged into "Ethics and caring", while "Diligence and hardworking" and "Nursing identity and dedication" were merged into "Accountability". Among these, "Diligence and hardworking" is the school motto, meaning that the students are expected to work hard, waste no time, and study perseveringly. Together with "Nursing identity and dedication", the intended meaning of "Diligence and hardworking" was therefore equivalent to "Accountability" as defined by the TNAC (Yu, 2010). The other five core competencies

including, “Basic biomedical science”, “Knowledge and skills”, “Critical thinking and reasoning”, “Communication and teamwork”, and “Life-long learning” are almost identical to TNAC’s core competencies, suggesting that the teaching aim of the school almost entirely corresponds to the ethos of TNAC. The only difference is that the school has an additional core competency, “Global view”, which represents the school’s aim to cultivate students’ global vision, so that they pay more attention to health-related issues and trends in the world.

Despite some differences in the classification of core competences or inventories based on the philosophy held by different professional organizations or nursing schools, all nursing education scholars seem to have a certain degree of consensus on the importance of applying outcome-based education as the fundamental basis for nursing program developed (Chin, 2010; Fan et al., 2015; Hsu, 2014; Hsu & Hsieh, 2009; Safadi et al., 2010).This study supported thatthe teaching aim of the school almost entirely corresponds to the ethos of TNAC and the process of this scale development can be a reference of the other schools.

CONCLUSION

Overall, this study followed the inventory development procedure to construct the CINS with 48-items and eight factors. The CINS Inventory involved focus group discussions, expert validity, and literature review for the establishment of the initial inventory; furthermore, the EFA and CFA were applied to examineits reliability and validity. The results from this current study indicated that the CINS appeared to be a fair reliable, valid, and suitable measure for the valuation of the core competencies for nursing students.

Limitations and suggestions

Although the inventory developed in this study have been validated using strict reliability and validity tests, only students from a technology university in northern Taiwan

were recruited due to limited personnel and time. Therefore, a limit of the present study is that it is unclear if the CINS is applicable to students from other areas. We suggest that future studies should recruit students from different areas to further validate this inventory, and investigate whether core competencies can be used to predict the clinical performance and retention rate of nursing graduates.

ACKNOWLEDGMENTS

This research was sponsored by the Ministry of Science and Technology (MOST 103-2511-S-255 -007) in Taiwan. There are no potential conflicts of interest relevant to this article to report.

We would like to thank Uni-edit (www.uni-edit.net) for editing and proofreading this manuscript.

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Table 1: Characteristics of study subjects (*n* = 1103)

Characteristic	n	%	Mean ± SD	Range
Gender				
Male	69	6.3		
Female	1034	93.7		
Age			21.05 ± 1.05	18–29
Four-year nursing bachelor degree program	586	53.1		
Sophomore	215	19.5		
Junior	206	18.7		
Senior	165	15.0		
Two-year nursing bachelor degree program	517	46.9		
Freshman	287	26.0		
Sophomore	230	20.9		

Table 2: Factor analysis of CINS of the calibration sample（n_1 = 569）

Item	Contents	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8
30	Have knowledge about the ethical issues in the health care environment	0.78							
32	Comply with ethical code and related legislations in the health care environment	0.76							
31	Investigate the ethical dilemmas in nursing	0.75							
33	Participate in the discussions about nursing ethical dilemmas	0.73							
28	Stick to the basic rules of ethics	0.71							
29	Protect the privacy and security of the target group	0.70							
25	Understand and respect the differences in multivariate cultures	0.54							
24	Respect and accept the uniqueness of the other people	0.54							
26	Apply professional skills in persons, families and communities	0.48							
27	Keep oneselfupdated with current affairs of the society and attend activities caring for vulnerable groups	0.45							
7	Collect the health data of target groups using nursing related knowledge		0.73						
6	Analyze the medical treatments of target groups using nursing related knowledge		0.71						

Item	Contents	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8
9	Plan the nursing interventions of target groups using nursing related knowledge		0.70						
8	Analyze the health needs of target groups using nursing related knowledge		0.69						
12	Evaluate the effect of health care		0.65						
10	Correctly apply different nursing skills		0.65						
5	Familiar with nursing related professional knowledge		0.64						
11	Offer individualized health education to target groups		0.61						
36	Cope with life and work issues with hard work			0.79					
35	Cope with life and work issues with a diligent attitude			0.78					
34	Cope with life and work issues with the spirit of simplicity and frugalness.			0.78					
37	Cope with frustrations with a positive and optimistic attitude			0.62					
38	Recognize your nursing identity and proactively act as a professional nursing personnel			0.52					
40	Measures that actively improve the nursing performance				0.69				
39	Can complete task efficiently and actively seek for measures to improve efficiency				0.66				
42	Make good use of sources and methods for self-development				0.61				

Item	Contents	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8
44	Apply the methods to improve self-development				0.61				
43	Analyze self-development outcomes and propose measures to improve self-development				0.56				
45	Ongoing proactive learning				0.53				
41	Analyze the pros and cons in self-development				0.48				
48	Form the habit of paying attentions to global health issues					0.86			
47	Understand the global nursing issues and trends					0.85			
49	Apply new international health care knowledge in professional practice					0.83			
46	Be updated with new professional knowledge in biomedical science and health care					0.70			
18	Use oral and written language to clearly express opinions						0.72		
17	Sense the need of the communication of target groups						0.67		
21	Establish good professional interpersonal relationships with target groups and health care teams						0.65		
20	Apply effective communication skills in personal interactions and analyze the outcomes						0.60		
22	Accept different opinions of other team members						0.53		
23	Examine the role and duty of oneself in the health care team						0.52		
2	Use basic biomedical knowledge to analyze the health needs							0.80	

Item	Contents	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8
	of target groups								
1	State the basic biomedical knowledge that is related to human health							0.76	
3	Use basic biomedical knowledge to analyze the medical treatment of the target group							0.75	
4	Appropriately apply basic biomedical knowledge in the target group's health care							0.68	
14	Conduct introspection on the personal way of thinking and able to self-adjust								0.72
16	Use credible information in discussions with other personnel								0.71
15	Use credible information to determine the approaches for solutions								0.68
13	Pose rational questions on the encountered issues								0.48
	Eigenvalue	5.41	5.26	4.49	4.28	3.86	3.84	3.19	2.94
	% of variance	11.27	10.96	9.35	8.92	8.05	8.00	6.65	6.13
	Cumulative % of variance	11.27	22.23	31.59	40.51	48.56	56.56	63.20	69.34
	Cronbach's α	0.933	0.909	0.925	0.926	0.924	0.889	0.895	0.840
	Name of factors	EC	KS	ACC	LL	GV	CT	BBS	CTR

Note: CINS = Competency Inventory of Nursing Students; EC = Ethics and caring; KS = Knowledge and skills; ACC = Accountability; LL = Life-long learning; GV = Global view; CT = Communication and teamwork; BBS = Basic biomedical science; CTR = Critical thinking and reasoning

Table3: Summary of fit indices from confirmatory factor analyses (n_2 = 534)

Fit indices	Desired values	Initial model	Final model
Likelihood-ratio χ^2 value)	(p (<0.05)	3842.938***	2781.154***
GFI	≧0.90	0.746	0.820
AGFI	≧0.90	0.717	0.800
SRMR	≦0.08	0.063	0.061
RMSEA	≦0.08	0.071	0.056
NFI	≧0.90	0.836	0.881
NNFI	≧0.90	0.866	0.916
IFI	≧0.90	0.875	0.922
CFI	≧0.90	0.875	0.922
PNFI	≧0.50	0.779	0.817
PCFI	≧0.50	0.816	0.855
Likelihood-ratio $\chi^{2/df}$	≦ 3	3.653	2.659

Notes: GFI = goodness-of-fit index; AGFI = adjusted goodness-of-fit index; SRMR = standardized root mean square residual; RMSEA = root mean square error of approximation; NFI = normed fit index; NNFI = non-normed fit index; IFI = incremental fit index; CFI = comparative fit index; PNFI = parsimony normed fit index; PCFI = parsimony comparative fit index; df = degree of freedom;

***p<0.001

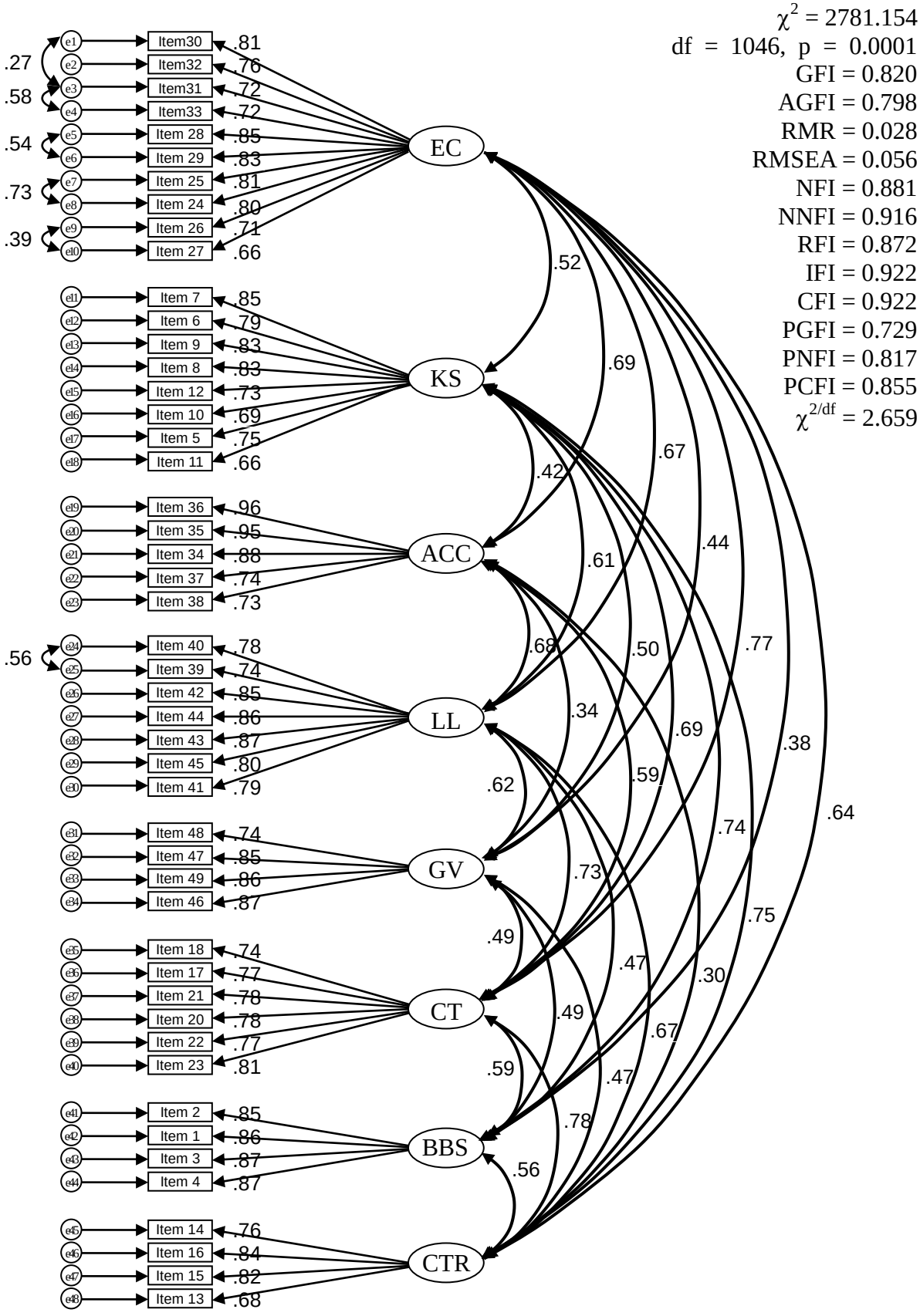

Figure1: Final measurement model of the CINS.