ORIGINAL RESEARCH

Revised competency inventory for evaluating nursing students

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ABSTRACT

Background and objective: To ensure high quality nursing education, a valid scale is needed to evaluate the core competences of nursing students. Insufficiencies of the Competency Inventory of Nursing Students currently used to measure competence in nursing students. The aim of this study was to revise Competency Inventory of Nursing Students and to validate its use for measuring competency in Junior college nursing students in terms of score distribution and dimensionality.

Methods: The scale was refined in a series of three phases performed during 2015-2016 in Taiwan: (1) established the item set via literature reviews and content validity testing; (2) refined the item set based on self-reported data from 120 nursing students and confirmed the factor structure by confirmatory factor analysis in 244 nursing students; (3) established the validity and reliability of the final scale.

Results: Analysis indicated that a 28-item scale with a 3-factor structure obtained the best fit to the data ($\chi^2 = 752.56$, $p < .001$, RMSEA = .069, SRMR = .043, CFI = .950, TLI = .946) and had an acceptable Cronbach α value (range .935 to .982). The strength of the inter-correlations among three latent variables was highly consistent with the conceptualization as a multifactorial construct.

Conclusions and implications: The revised scale has satisfactory validity and reliability for measuring core competency in nursing students. Implications for practice: For employers concerned about the competency of recent graduates of associate degree nursing programs, the effective and comprehensive scale can be used for self-evaluation of competency in nurses and can also provide feedback for improving teaching and learning efficiency during the education of nurses.

Key Words: Competency, Nursing student, Scale refinement

1. BACKGROUND

Nurses are healthcare professionals entrusted with protecting patients from sickness or pain. Doing so may require them to play various roles, including teacher, advocate, caregiver, critical thinker, and innovator. However, studies have shown that nursing graduates were not ready for practice for the workforce.[1] To prepare nursing students for real world practice, nursing schools and various employers in the healthcare industry have attempted to define and validate essential entry-level competencies. Nursing competency has been conceptualized as a journey rather than as a destination.[2] The previous learning experiences of nursing students can play a role in developing competent nursing practice.[3] Profiling the competency of student can help to motivate them to achieve improved performance from a self-directed learning perspective.[4]

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Although the terms competence and competency are used interchangeably in the literature, competency is defined as the actual performance in a given situation.[5] However, to evaluate students' learning and outcomes with limited time and resources, self-reported measures are still widely used tools compared to measures that only use a few sets of objective clinical data.[6] Thus, a valid scale for measuring competency in nursing students can be used for curriculum evaluation and for students' own learning assessment.

Nursing is a knowledge based professional discipline[2] with core standards for practice.[7] Competency in nursing is multifaceted and practice-based, depending on the clinical specialty of the practicing nurse.[8] According to Higher Education Evaluation and Accreditation Council of Taiwan,[9] the core competencies for either associate degree or bachelor nursing students include the following eight competencies: critical thinking and reasoning, general clinical skills, basic biomedical science, communication and team work capability, caring, ethics, accountability and life-long learning.

Currently there are two scales based on the eight core competencies developed by Hsu and Hsieh for measuring competency in nursing students: a two-dimension 8-item Core Competencies Scale (CCS)[10] and six-factor 43-item Competency Inventory of Nursing Students (CINS).[11] However, the CCS does not have a sufficient number of items for use in curriculum design or to serve as a self-evaluation tool that students can use to continue improving their practice. The CINS although it has many items, the six-factor structure has not been tested with confirmatory factor analysis (CFA). The CINS also does not include items related to teaching competency. Individual patient education is expected for a graduating clinical nurse in Taiwan.[12]

The CINS has not been validated for associated degree prepared nursing students. In Taiwan, approximately 75% of the nursing programs are at the associate degree level designed to provide graduates with the basic technical knowledge needed to deliver competent patient care.[13] Nursing education programs in Taiwan widely vary from 5-year programs in junior colleges and 2- and 4-year programs in universities. Theoretically, the nursing competency achieved by students in different programs should differ. Few studies have performed psychometric evaluations of instruments for measuring competency in associate degree nursing students. Finally, an evaluation of competencies should be sensitive to changes in self-assessment of competence. Developing an effective research instrument requires an ongoing process of refinement to establish validity, reliability, and stability. Thus, to fill the research gap, this study refined the CINS to include teaching competence and tested the revised CINS in associate degree nursing students.

2. METHODS

A cross-sectional descriptive design to refine the CINS was conducted in two phases: item revision and reliability and validity testing.

2.1 Phase 1: Item revision

Initially, a 51-item CINS was developed from the original 43-item CINS, and eight items added across dimensions based on the eight core competencies required to graduate from nursing school in Taiwan. The eight items including items in NCQ and interview with student and clinical nurse. For example, two items were added to the caring dimension: "reflection on communication with team" (NC27) and "assisting clients in communicating with team" (NC28); two items were added to the biomedical science dimension: "integrating medical knowledge in assessment of clients" (NC6) and "knowing how to assess clients" (NC7); one item was added to the general clinical skills dimension: "conducting patient education" (NC15); one item was added to the critical thinking dimension: "identifying and acting on abnormal changes in patients" (NC20); two items were added to the lifelong learning dimension: "enjoying oneself and appreciating the nursing role in others" (NC49) and " sharing nursing experience with peers" (NC50).

Additionally, some items were refined according to suggestions by educators. Two items, "I know where and how to look for resources for learning" (NC51) and "I make use of technology and other resources in learning" (NC52), were merged into, "I can search for references or resources for learning" (NC48). One item was refined to avoid repetition: "I abide by the nursing related rules and regulations" (NC29). Three items were refined to focus on skill performance instead of cognition to maintain consistency with graduation level or curriculum objectives: "I can explain the mechanisms and side effects of medicine" (NC3), "I can judge when patients have normal results in clinical examinations" (NC4), and "I can modify a nursing intervention according to the response of the patient" (NC12).

Thus, the 50 items in the initially modified version of the CINS, include basic biomedical science (7 items), general clinical nursing skills (8 items), critical thinking (5 items), caring (8 items), ethics and accountability (16 items), and lifelong learning (6 items). For each item, competency was rated on the following 7-point Likert scale: 1 (none), 2 (deficient), 3 (poor), 4 (minimum required), 5 (fair), 6 (good), 7 (complete). Total scores ranged from 50 to 350 points. The original survey was written in Chinese.

Next, the content validity of the 50-item revised CINS was tested. Five content experts, including one nursing educator and four head nurses, were asked to rate each item in terms of relevance and clarity of wording on a scale from 1 (none) to 4 (high). Items with scores of at least 3 were retained. Content validity was established by an average item-level content validity index of 1 and by an average scale-level content validity index of 1.[14] Face validity was also established by asking three students to complete the test and then comment on the clarity of wording for each item.

2.2 Phase 2: Reliability and validity testing

Phase 2 aimed to test the psychometrics of the instrument developed during the Phase 1. Out of 455 students in the final semester of the associate's degree program were invited to participate, 80% provided written informed consent. Ten participants did not give complete data, which resulted in an effective response rate of 97.5%. The sample for this study comprised 364 senior junior college nursing students who participated voluntarily and completed questionnaires. Most (98.0%) of the respondents were female and the mean age was 18.97 years (SD .75). This study was performed during 2015-2016 in Taiwan.

2.3 Ethical considerations and data collection

After obtaining approval from the Internal Review Board. Potential participants were invited to participate. No names of participants were collected to ensure confidentiality. Students who consented to participate received the questionnaires. All participants were given adequate time to respond and the questionnaires were returned to the research assistant during class time.

2.4 Data analysis

Exploratory factor analysis (EFA) and CFA were performed to explore and validate the refined CINS as suggested in the literature.[15] The appropriate sample size at least of 300 was suggested in the literature.[16–18] A subsample of 120 was used for EFA by using SPSS software (version 17.0) while the remaining sample (n = 244) was used to determine the factor structure by using Analysis of Moment Structures (AMOS) version 21 to perform CFA.

3. Results

3.1 Score distribution

The score distribution was first evaluated according to floor and ceiling effects by calculating the highest and lowest possible scores for the items. Floor and ceiling effects were defined as more than 15.0% of respondents with the lowest possible scores and more than 15.0% of respondents with the highest possible scores, respectively.[19] Thirteen items showed ceiling effects (see Table 1). The D'Agostino test[20] of normality in the distribution of scale scores showed that all items had a normal distribution except item 32 and item 42.

3.2 Item analysis and homogeneity

The overall homogeneity of the 50-item revised CINS was satisfactory. The item discrimination indices for all items (range, 7.77-14.55) exceeded the recommended minimum of 3, and the range of corrected item-total correlation coefficients varied between .65 and .86 and by at least .30.[21] A 50-item scale was then further analyzed to estimate construct validity by EFA and CFA.

3.3 Exploratory factor analysis (EFA)

The Kaiser-Meyer-Olkin measure of sampling adequacy for factor analysis was excellent at .937. The Bartlett test showed that the correlation matrix was unlikely to be an identity matrix (Bartlett χ^2 = 4,364.496, $p < .001$). Therefore, the 50-item set was suitable for factor analysis.[22] In EFA of the Revised CINS, a scree slope plot of eigenvalues revealed four factors. An EFA (using principal axis factor extraction with Varimax rotation and three factors) was also performed (see Table 2). Next, twenty items with factor loadings under .5 or cross-loadings on other factors were excluded. In the three-factor structure, factor loading ranged from .52 to .92, and the Cronbach alpha values for the factors ranged from .94 to .98. Three factors with 30 items accounted for 77.6% of the variance in nursing competency.

3.4 Confirmatory factor analysis (CFA)

The predicted model obtained by EFA was examined by using AMOS to perform CFA. The data showed no violations of multivariate normality assumptions with values ranging from -.45 to .23 for skewness and from -.72 to .15 for kurtosis.[23] However, the overall model fit indices showed an unacceptable fit (RMSEA .069, SRMR .043, CFI .950, TLI .946). Based on the modification indices, two items (NC2, NC37) that were double loaded on both latent variables were rejected. Figure 1 shows that the final model included 28 observed variables and three latent constructs. Table 3 shows that the model had a good overall fit according to the criteria suggested by Tabachnick and Fidell.[22] A high and statistically significant chi-square value is expected when the sample size is large.[24] A chi-square value is considered acceptable if it does not exceed five times the degrees of freedom (χ^2/df), i.e., if it does not exceed the normed chi-square.[25] The fit indices of the internal structure model were also acceptable.[26] Item reliability exceeded .25 (range, .54 to .91), composite reliability exceeded .60 (range, .94 to .96), average variance extracted exceeded .50 (range, .68 to .86), and three factor loadings ranging from .74 to .96 accounted for 75.4% of the variance in nursing competency.

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Table 1. Item distribution of responses and homogeneity of the revised CINS (n = 150)

Revised Items (original or added)	Corrected item-total correlation	α If item deleted	Median (q1-q3)	Lowest score, %	Highest score, %
Biomedical science					
NC1 (1)	.735	.987	4 (4-5)	0.0	1.3
NC2 (2)	.677	.987	4 (4-5)	0.0	1.3
NC3 (R3)	.703	.987	5 (4-5)	0.0	3.3
NC4 (R4)	.708	.987	4 (4-5)	0.0	0.7
NC5 (5)	.743	.986	4 (4-5)	0.0	1.3
Clinical skills					
NC6 (added)	.636	.987	4 (4-5)	0.0	2.0
NC7 (added)	.707	.987	4 (4-5)	0.0	2.7
NC8 (6)	.784	.986	5 (4-6)	0.0	6.0
NC9 (8)	.755	.986	5 (4-5)	0.0	2.0
NC10 (9)	.782	.986	5 (4-5)	0.0	2.0
NC11 (10)	.817	.986	5 (4-5)	0.0	2.7
NC12 (R11)	.810	.986	5 (4-5)	0.0	1.3
NC13 (13)	.802	.986	5 (4-6)	0.0	2.7
NC14 (14)	.774	.986	5 (4-5)	0.0	2.0
NC15 (added)	.750	.986	5 (4-5)	0.0	4.0
Critical thinking					
NC16 (21)	.752	.986	4 (4-5)	0.0	2.7
NC17 (22)	.719	.987	4 (4-5)	0.0	2.7
NC18 (23)	.752	.986	4 (4-5)	0.0	2.0
NC19 (25)	.684	.987	4 (4-5)	0.0	1.3
NC20 (added)	.771	.986	4 (4-5)	0.0	3.3
Caring and communication					
NC21 (26)	.823	.986	5 (4-6)	0.0	5.3
NC22 (27)	.822	.986	5 (4-6)	0.0	8.0
NC23 (28)	.827	.986	5 (4-6)	0.0	6.7
NC24 (29)	.789	.986	5 (4-6)	0.0	5.3
NC25 (30)	.821	.986	5 (4-6)	0.0	10.7
NC26 (31)	.783	.986	5 (4-6)	0.0	20.0
NC27 (added)	.813	.986	5 (4-6)	0.0	3.3
NC28 (added)	.792	.986	5 (4-6)	0.0	2.7
Ethics					
NC29 (R32)	.778	.986	5 (5-6)	0.0	20.7
NC30 (33)	.766	.986	5 (5-6)	0.0	18.0
NC31 (34)	.781	.986	5 (5-6)	0.0	18.0
NC32 (35)	.767	.986	6 (5-6)	0.0	22.7
NC33 (36)	.777	.986	6 (5-7)	0.0	27.3
NC34 (37)	.720	.987	5 (4-6)	0.0	14.0
NC35 (38)	.758	.986	6 (5-6)	0.0	17.3
NC36 (39)	.768	.986	6 (5-6)	0.0	17.3
NC37 (40)	.780	.986	6 (5-7)	0.0	26.0
Accountability					
NC38 (41)	.768	.986	6 (5-6)	0.0	22.7
NC39 (42)	.765	.986	6 (5-6)	0.0	16.0
NC40 (43)	.815	.986	5 (5-6)	0.0	13.3
NC41 (44)	.843	.986	5 (4-6)	0.0	7.3
NC42 (45)	.782	.986	6 (5-6)	0.0	15.3
NC43 (46)	.813	.986	6 (5-6)	0.0	15.3
NC44 (47)	.745	.986	5 (4-6)	0.0	4.0
Lifelong learning					
NC45 (48)	.784	.986	5 (4-6)	0.0	8.7
NC46 (49)	.807	.986	5 (4-6)	0.0	7.3
NC47 (50)	.770	.986	5 (4-6)	0.0	6.0
NC48 (51+52)	.729	.987	5 (4-6)	0.0	5.3
NC49 (added)	.779	.986	5 (5-6)	0.0	14.0
NC50 (added)	.821	.986	5 (5-6)	0.0	14.7

Note. R, stand for revised

Table 2. Factor loadings from EFA

Item	Factor 1	Factor 2	Factor 3
NC1.	.818		
NC2.	.802		
NC3.	.735		
NC4.	.700		
NC5.	.818		
NC6.	.808		
NC7.	.696		
NC9.	.729		
NC10.	.745		
NC11.	.771		
NC14.	.723		
NC15.	.688		
NC16.	.690		
NC17.	.661		
NC19.	.683		
NC29.		.860	
NC30.		.878	
NC31.		.824	
NC32.		.871	
NC33.		.918	
NC34.		.756	
NC35.		.858	
NC36.		.784	
NC37.		.879	
NC38.		.819	
NC44.			.523
NC45.			.696
NC46.			.639
NC47.			.766
NC48.			.797
Initial Eigenvalues	18.21	3.56	1.53
Percentage of Explained Variance	60.69%	11.88%	5.09%
Rotation Sums of Squared Loading	9.70	9.19	3.74

3.5 Second-order factor analysis

After CFA, this study investigated whether the revised CINS could be viewed as a higher order construct of the three dimensions (professionalism, ethical-literacy, and lifelong learning). A second-order model used three CFA dimensions, and the lambda value for each dimension was set to 1.0. Figure 2 shows the factor loadings and gamma values for the second-order model. The fit indices were consistent with the CFA results. The above results strongly supported the use of the revised CINS as a high-order construct in assessment of competency in junior college nursing students.

3.6 Testing convergent validity and reliability

Convergent validity was tested with the Visual Analogue Scale (VAS), which is a 10-mm horizontal line anchored by numbers and word descriptors at the right end, middle, and left end of the line (0 = no competence, 50 = moderate competence, 100 = high competence, respectively). Participants were asked to indicate the point on the line that best represented their current nursing competency. Perceived nursing competency on the VAS significantly correlated with that on the 28-item revised CINS (r = .401, p < .000). The r values for the three subscales of the revised CINS were .90, .84, .83 (p < .000), respectively.

The total scale and subscales also showed a high internal consistency of items representing the competence of nurses and nursing students. The overall inter-item correlation ranged from .28 to .90, and total-item correlation ranged from .678 to .82. The stability of the revised CINS was confirmed by analysis of test-retest reliability in forty-six students who completed the questionnaire after the first administration, which showed a correlation coefficient of .71 (p < .000) and an intra-class correlation of .83 (95% CI .70 - .91).

4. Discussion

4.1 Study limitations

The generalizability of this study is limited by the use of a purposive sample of graduating nursing students at one junior college for preliminary refinement of the scale. Thus, further evaluations in other junior college nursing students or other nations are needed to confirm the external validity of the model and the predictive validity and applicability of the revised CINS.

The wording used for scoring metrics is likely to induce a social desirability effect that overestimates participants' competency. For example, participants are asked to rate their competency on a scale of 2 to 3 for lack of competency and poor competency, respectively. For social acceptability, they might tend to rate their competency as 4. To minimize the social desirability effect and 'faking good' effect, which can reduce the construct validity of the questionnaire, the participants in this study were instructed to respond honestly and anonymously and were given enough time to complete the questionnaire. Nevertheless, further studies are needed to advance both the research and practice related to competency in nursing students. For example, the vulnerability of a self-reported measure to social desirability may be decreased by using words that minimize sensitivity to social desirability bias or by administering a Social Desirability Bias Scale.[27]

4.2 Validity of the revised CINS

The revised 50-item CINS proposed in this study was based on relevant instruments and the literature. After the first-order factors (28 items) were confirmed by CFA as a broader construct, the proposed three-factor structure model was confirmed by hierarchical CFA related to a higher order factor, i.e., the nursing competency construct. The results indicated that the revised CINS had good construct validity. Validity

was also supported by a correlation coefficient ranging from .56 to .69 among three factors, i.e., the three latent variables used to measure the same construct of core competence. The final model of the 28-item set converged to an acceptable solution, and overall and internal structure model fit indices indicated that the revised CINS model had a good fit to the observed data, i.e., the model was cross- validated with new data. Additionally, the model was consistent with the definition of competence for entry-level nurse,[28] which indicated that nurses can use their knowledge, skills, judgment, and attitudes to practice nursing safely and ethically.

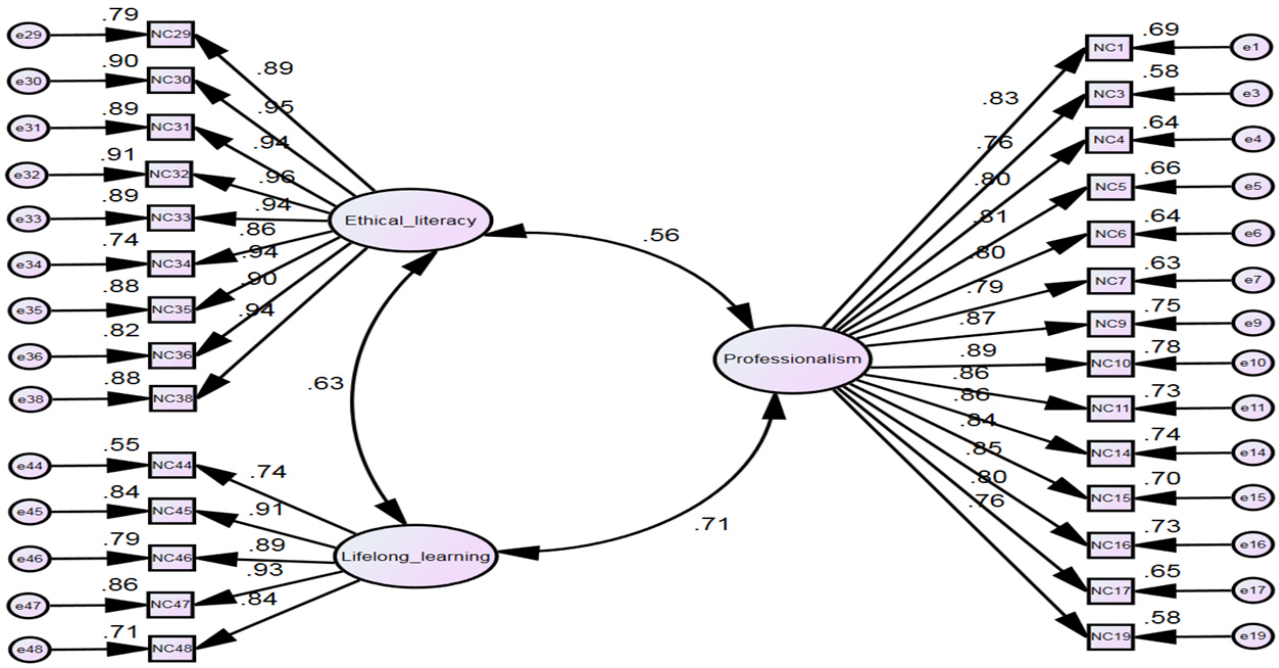

Figure 1. Final measurement model of the revised CINS

Table 3. Overall model fit indices for CFA and second-order CFA of the revised CINS

Fit index (desired value)	Initial model	Final model	second-order CFA
RMSEA (< .08)	.086	.079	.080
SRMR (< .05)	.052	.049	.060
CFI (> .90)	.895	.919	.916
TLI (> .90)	.889	.913	.910
χ^2 (p > .05)	2,016.96, p < .001	1,374.15, p < .001	1,410.30, p < .001
χ^2 /d.f. ratio (< 5)	2.748	2.480	2.537

Note. RMSEA, Root Mean Square Error of Approximation; SRMR, Standardized Root Mean Square Residual; CFI, Comparative Fit Index; TLI, Tucker-Lewis index

Compared with the original CINS, the revised CINS had fewer factors and items but a slightly higher total explained variance. The three-factor structure including professionalism, ethical-literacy, and lifelong learning was congruent with the International Council of Nursing framework for competences in generalist nurses,[29] which includes both processes of nursing practice (i.e., assessment, diagnosis, planning, implementation, and evaluation) and professional performance (i.e., ethics, education, evidence-based practice, and resource utilization). The factor structure of this scale is congruent with the Nursing Process Theory that the nursing process is an effective and systematic approach to administering actual or potential patient care. Competency in applying the nursing process can facilitate critical reasoning since the nursing process involves eight elements of critical thinking.[30] Therefore, the professionalism subscale, which measured standard procedures for nursing practice and professional performance, can provide the foundation and scope of nursing competency when evaluating competency in nursing students and can guide them in developing entry-level competency. The results also supported the Taiwan Technical and Vocational Education Act,[13] which requires

basic vocational education to provide students with the professional knowledge, skills, and professional ethics required to join the workforce and to establish a sense of pride in their technical or vocational profession. Similarly, the study confirmed the core competencies of nursing as the systematic skills and/or integrated abilities that nursing students required for a nursing practice.[31]

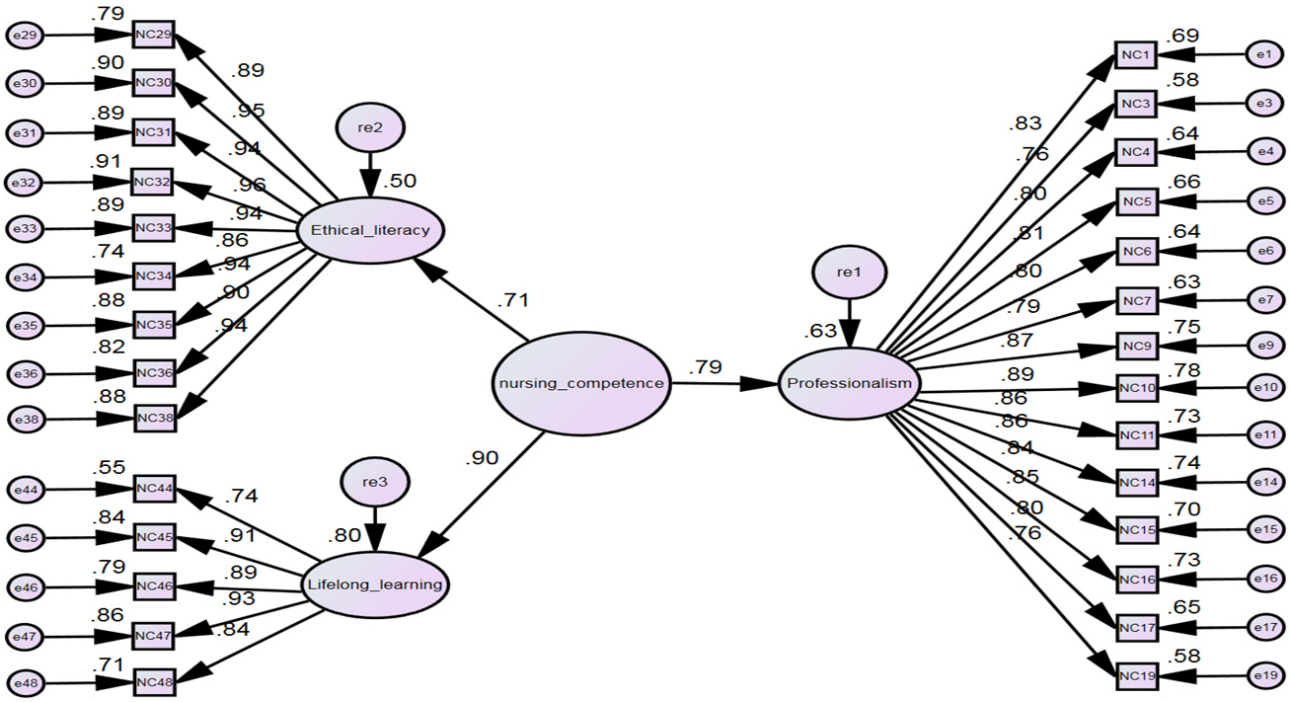

Figure 2. Second-order model of the revised CINS

Although it did not include items in the caring subscale, the revised CINS is consistent with the parsimony principle of combining four factors (caring, clinical skills, biomedical science and critical thinking) into a single factor (professionalism). For example, items in the caring subscale were deleted to prevent cross-loading on either ethics or professionalism. The percentage of total variance for the 14-item professionalism factor (57.7%) exceeded those for the other three factors, which indicated that professionalism was the best indicator of nursing competency. Unlike the 22 accumulated items, including factors of caring, biomedical science, clinical skill, and critical thinking in the original CINS, explained only 17.1% of the variance in the overall original scale. These data are consistent with Missen et al.,[32] who claimed that the clinical competence of new nursing graduates is specifically related to their critical thinking and technical skills. Also in consist with some of nursing competency (management, professionalism, problem-solving, nursing process, and knowledge of basic skills) in a 27-item Competence Assessment Scale[33] and the attributes of nurse competence (integrating knowledge into practice, critical thinking, proficient skills, and professionalism).[2] Of the eight items added to the revised version of the CINS, three items kept were all related to professionalism (NC6, 7, 15) including patient education.

Ethical competence is the root of the professional discipline of nursing in the sense that it is good for society.[34] For many nursing regulatory groups worldwide, competence or literacy in ethics is required for a license to practice nursing. The 9-item "ethical literacy" competency in this refined scale is similar to the "ethical practice" competency measured by the Canada's Competencies in the Context of Entry-Level Registered Nurse[35] and "prioritize people" in United Kingdom's code for Nurses,[7] such as "respects and preserves clients' rights", "promotes a safe environment for clients", "minimize the potential influence of personal values", "provides care for all clients", "Respect people's right to privacy and confidentiality". Comparing with the original CINS which included 15 items and explained 49.2% of the variance in the overall scale, the factor 2 "Ethical literacy" included 9 items and explained 13.6% of the variance in the overall scale. Items in this subscale were deleted to prevent cross-loading on Lifelong learning. Another possible reason why these 15 items remained in the original "Ethical and responsibility" subscale is that CFA was not performed.

Factor 3, "Lifelong learning", contained 5 items and explained 4.6% of the variance in the overall scale, which was consistent with the original CINS, in which 5-item lifelong learning explained 3.4% of the variance in the overall scale.[11] The data were also consistent with a previous report that student nurses should be given learning opportunities to foster improvement of the skills and knowledge needed for personal growth, such as searching for resources, seeking answers, setting goals, problem inquiry, and managing time.[36] However, two added items failed to keep in this scale. Participants in this study might have responded to these items from a perspective other than lifelong learning.

4.3 Implications for nursing education and research

A sensitive and continuously refined instrument tailored specifically for nursing students has many applications, including assessment, evaluation and ongoing development of curriculum. According to Self-directed Learning Theory,[37] a self-reported instrument can serve not only as an evaluation tool, but also as a way to define the tasks or goals that the respondent requires for future learning. Nurse trainers must assess the competency of their students in professionalism, ethical literacy, and lifelong learning. One way to do so is to use questionnaire surveys to assess nursing competencies before training so that training programs can be modified accordingly. The findings of this study also have important implications for future research. For example, further research is needed to develop additional observational instruments for measuring nursing competence and to validate them in comparison with self-reported instruments that are less sensitive to social desirability bias.

5. Conclusion

The objective of this study was to refine, modify and evaluate the score distribution and dimensionality of the CINS for use in nursing students in associate degree program. In conclusion, results from EFA and CFA illustrate three essential competencies (professionalism, ethical literacy, and lifelong learning) that should be measured for graduates of an associate degree in nursing program in relation to quality education and nursing standards. The corresponding subscales of the refined CINS may provide the nursing educator a method for assessing knowledge and capacity acquisition. Further the revised and refined CINS will ensure that entry-level registered nurses are well-equipped with the competencies needed to function and adapt to changes in the healthcare system of today. The refined CINS model may be applied to provide students' guidance in developing competencies for professional development.

Conflicts of Interest Disclosure

The authors declare that there is no conflict of interest.

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