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Research article

Integrated measure for training transfer in nursing practice: Development and validation study

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ABSTRACT

Background: The persistent knowledge-practice gap in nursing, where competencies gained through continuing professional development fail to integrate into practice, remains a significant challenge. Effective transfer of acquired knowledge and skills to the workplace is essential for bridging this gap. However, there is a lack of comprehensive, validated instruments to assess factors influencing training transfer in nursing practice.
Objective: This study aims to develop a questionnaire capable of assessing training transfer as an integrated construct, encompassing all factors influencing this process in nursing practice.
Design: The study followed a developmental, iterative approach guided by the COnsensus-based Standards for the selection of health Measurement INstruments (COSMIN).
Setting(s): Eight tertiary teaching hospitals in the Netherlands.
Participants: Educational experts ($n = 8$) and nurses ($n = 1588$).
Methods: The questionnaire development consisted of three phases: Phase 1) content development, in which instruments were identified based on a literature study and translation of included instruments into Dutch, Phase 2) pilot phase: content validation and usability testing using Delphi studies with experts and nurses, Phase 3) psychometric validation: construct validation using exploratory and confirmatory factor analysis, composite reliability and discriminant validity. The phases were completed from January 2023 till June 2024.
Results: The literature review led to the inclusion of two key instruments: the Learning Transfer System Inventory (LTSI) and the Learning Climate Questionnaire (LCQ). Following item reduction based on Delphi rounds, nurses completed the adapted instruments. Psychometric validation demonstrated a good fit for these instruments in nursing practice. The adapted LTSI showed loadings ranging from 0.37 to 0.99, with a Normed X2 of 1.996, TLI of 0.908, CFI of 0.920, and RMSEA of 0.050 [CI = 0.047–0.054]. The adapted LCQ exhibited loadings from 0.64 to 0.94, with a Normed X2 of 3.385, TLI of 0.963, CFI of 0.974, and RMSEA of 0.069 [CI = 0.061–0.078]. The combined model demonstrated a Normed X2 of 2.014, TLI of 0.900, CFI of 0.907, and RMSEA of 0.051 [CI = 0.048–0.054].
Conclusions: The adapted LTSI and LCQ, both separately and combined, are reliable and valid instruments for use in the Dutch nursing hospital context. Together, they provide a comprehensive assessment of factors influencing training transfer. They can also be used independently to examine specific components such as trainers (LCQ), context (LTSI), personal aspects (LTSI), or training (LTSI/LCQ). Furthermore, these instruments can facilitate discussions between nurses, managers, and educational experts to address barriers to training transfer in nursing practice.

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1. Background

The nursing workforce is an important asset of knowledgeable healthcare organizations. Safe and high-quality care is predominantly dependent on the ongoing ability of nurses to acquire and implement new knowledge and skills. To support continuous learning, hospitals invest in various educational programs aimed at enhancing nursing competences (Torunn Bjørk et al., 2013; Yun et al., 2019). One way to achieve this is by continuing professional development (CPD). CPD is defined as: *"a life-long process of active participation by nurses in learning activities that assist in developing and maintaining their continuing competence, enhancing their professional practice and supporting achievement of their career goals"* (Pool, 2015, p. 15). CPD encompasses both formal and informal learning; formal learning involves structured activities, while informal learning occurs spontaneously during daily work activities (Eraut*, 2004; Laal, 2011).

Despite these efforts, a persistent challenge in nursing education is the knowledge-to-practice gap. Although the knowledge-to-practice gap is well investigated in wide range of areas, in this study it focusses on the gap where knowledge, skills and attitudes acquired through CPD fail to be integrated into nursing practice (Ajani and Moez, 2011; Gassas, 2021). Addressing this gap requires facilitating the transfer of acquired knowledge and skills to the workplace, enabling nurses to apply their developed competencies effectively (Graham et al., 2006). Transfer of training is defined as *"the extent to which knowledge, skills and abilities learned in work-related training are generalized and maintained on the job"* (Bates et al., 2012, p. 549). This transfer is influenced by numerous factors and is described by various models, the most notable being the dynamic transfer model (Blume et al., 2019). This model, which includes individual, contextual and training-related influencing factors, is grounded in extensive research, including three reviews describing the known and unknown of transfer research in each decade (Baldwin and Ford, 1988; Blume et al., 2010; Blume et al., 2019; Ford et al., 2018).

In the Netherlands, a systematic approach is lacking for CPD of nurses after graduation, because participation in learning activities is not a mandatory requirement for working. However, before policies can be adjusted, it is necessary to understand which factors influence CPD in nursing practice. Although the dynamic transfer model is well researched, there is a gap in the availability of comprehensive, well-validated instruments for assessing training transfer in nursing practice within Western contexts. Several instruments have been developed to assess factors influencing the transfer of training across different settings (Bai et al., 2018; Holton Iii et al., 2000; Machin and Fogarty, 2004; Rouiller and Goldstein, 1993; Thayer and Teachout, 1995). However, challenges remain, such as the difficulty in generalizing and extrapolating results towards nursing practice due to varied scales and settings, and methodological limitations like inadequate construct validation and suboptimal psychometric properties. To our knowledge the only instrument for nursing practice is the validated Factors Influencing Transfer of Training (FITT) questionnaire (Bai et al., 2018), developed in a Chinese setting, and lacking cross-cultural validation. Consequently, this study aims to develop a questionnaire to assess factors influencing transfer of training in nursing practice.

2. Method

2.1. Design

This study employs a methodological research design aimed at developing and validating a questionnaire, following an iterative approach based on the COnsensus-based Standards for selection of health Measurement INstruments (COSMIN) (Mokkink et al., 2006). It consisted of the following three phases: 1) content development, in which instruments were identified based on a literature study and included instruments were translated into Dutch, 2) pilot phase, including content validation and usability using Delphi studies with educational experts and nurses, 3) psychometric validation including construct validation, using exploratory and confirmatory factor analysis, and testing composite reliability and discriminant validity. The steps were followed from January 2023 till June 2024 (Fig. 1).

2.2. Study population, setting and sample size

Different participants were included in the different phases and steps. During the pilot phase (phase 2) educational experts were included, using purposive sampling strategy. This allowed local researchers to include eligible educational experts that could contribute to the further development of the questionnaire. Educational experts were eligible when they had expertise and were affiliated with professional development of nurses. The pilot phase also included three nursing groups, using purposive sampling strategy: 1) newly graduated nurses, 2) experienced nurses, 3) experienced nurses with ambitions for advances roles. These three nursing groups were identified in a scoping review that showed that they experience different facilitating and inhibiting factors in their CPD (Hakvoort et al., 2022). With the inclusion of these three nursing groups a heterogenic population was included in the pilot phase. In phase 3 (psychometric validation) eligible nurses were included using a convenience sampling strategy. Registered nurses were included without further defining inclusion criteria, in order to include a broad range of nurses in each hospital. Nursing students were excluded. All participants worked in one of the hospitals affiliated with the RENurse consortium. The RENurse consortium includes 14 tertiary teaching hospitals located throughout the Netherlands. For this study, eight RENurse hospitals participated. Sample sizes for psychometric validation varies in the literature. Some authors suggest a minimum of 10 cases per item, others suggest a minimum of 150 or 200 cases in total. A sample size of 500 is considered very good and 1000 is excellent (Cohen et al., 2002). Therefore all hospitals aimed at including at least 75 nurses to comply with suggested minimums in literature.

2.3. Phase 1: content development of a preliminary questionnaire

A systematic literature search was conducted to operationalize the construct 'transfer of training'. The literature search focused on existing, validated instruments and underlying constructs that measure transfer in healthcare training contexts. Then, three researchers within the research team independently scored the identified instruments on in- and exclusion criteria. Identified instruments were included if: 1) they met the COSMIN criteria in their development, 2) they sufficient met the theoretical model that is used in this study (Dynamic transfer model: individual, training and contextual influencing factors), 3) they were not specifically developed for undergraduates. In step two included instruments were translated into Dutch within the research team. One of the researchers translated the items into Dutch and a second researcher checked the translations. Next, the translated items were discussed within the research team. After item reduction the included instruments were sent to a Dutch language expertise centre who assessed the lingual aspects of the items.

2.4. Phase 2, pilot phase: content validation and usability

For the content validation of the included instruments (Step three and four) educational experts were included. All experts were asked to rate the relevance of the items based on the method of Lynn (irrelevant, mainly not-relevant, mainly relevant and highly relevant, step three) (Lynn, 1986). In addition, they were asked to assess the comprehensibility of the items on a scale from 1 to 10, where a score of 1 indicated low comprehensibility, and a score of 10 indicated high comprehensibility. The experts were also asked whether the items covered the entire construct measured. The Item-Content Validity Index (I-CVI) was used to quantify the relevance of the items. The I-CVI refers to the number of

experts who defined the content relevant. All scores were dichotomized into relevant (scores mainly relevant and highly relevant) and not relevant (scores irrelevant, mainly not-relevant). Next, the I-CVI was calculated: sum of the relevant scored items divided by number of experts. An item has excellent coverage when the I-CVI $\geq$ 0.78 (Lynn, 1986; Polit and Beck, 2006; Polit et al., 2007). However, I-CVI scores between 0.70 and 0.79 need revision and if the value is below 0.70 it is opted for elimination (Zamanzadeh et al., 2015). Within the research team a more conservative cut-off was used (I-CVI $<$ 0.5), because items were not newly developed but included from existing instruments that were well used and validated in different settings. Besides the I-CVI $<$ 0.5, the research team also considered the number of items that represented the original constructs of the included instruments. If, after exclusion of an item the construct was insufficient represented by other items, the item remained included during this step. Readability and comprehensibility (Step four) was measured with a mean score. Based on the I-CVI score, the mean scores of the readability and comprehensibility and qualitative feedback regarding comprehensiveness the research team discussed the in- and exclusion of the items.

Next, in step six the three nursing groups (newly graduated nurses, experienced nurses and experienced nurses with ambitions for advanced roles) were included for the pilot testing (readability and face validity). The nurses filled in the items as well on paper as digital to assess face validity and readability of the items, but also the digital environment in which the items were included. All nurses were asked to give feedback on readability and comprehensibility. The time nurses needed to fill in the items was measured. Phase two resulted in a final set of items for the included instruments.

2.5. Phase 3, psychometric validation: construct validation

The construct validation of the included instruments consisted of an exploratory factor analysis (EFA), including safety checks for assumptions underpinning factor analysis (step 7) and a confirmatory factor analysis (CFA) including Structural Equation Modelling (SEM) (step 8).

To gather data for psychometric validation the final version of the included instruments was sent to eight tertiary teaching hospitals. Local researchers distributed the instruments in their hospital with the Enalyzer tool (www.enalyzer.com). Nurses received a digital link to the instruments and were asked to answer the questions thinking of their last training course taken.

Assumption checks were carried out regarding: sample size, ratio of sample size to number of items, sampling adequacy, intercorrelations between variables, intercorrelations between factors, distribution and outliers (Cohen et al., 2002). Next, the data file was split in half and an EFA was conducted on the first half. The EFA allowed to seek and explore underlying patterns, clusters and groups. With the second half of the dataset a CFA was conducted. The CFA allowed for the testing of the set of factors that were identified in the EFA, against a hypothesized model, in this case the dynamic transfer model (Blume et al., 2019).

Ethical approval was obtained from the ethics medical board of MMC (Maxima Medical Center) in Brabant, the Netherlands (2023-MMC-081). Written informed consent was obtained in Step 3 from the educational experts. All nurses consented for participation at the start of the digital questionnaire.

3. Results

3.1. Phase 1: content development of a preliminary questionnaire

The exploring literature search led to the identification of several instruments widely used, an overview is provided in supplementary material Table 5. Two instruments scored positive on all inclusion criteria (COSMIN, theoretical model and population) and were therefore included: 1) the Learning Transfer System Inventory (LTSI) (Holton Iii et al., 2000; Holton Iii et al., 1997) to measure transfer of training and 2) the Learning Climate Questionnaire (LCQ) to measure learning climate (Williams and Deci, 1996). The LTSI has been validated in various situations and contexts, but also has some methodological limitations concerning psychometric characteristics and is not validated in nursing practice(Bates et al., 2012; Bates et al., 2007; Chen et al., 2005; Devos et al., 2007; Holton Iii et al., 2000; Holton Iii et al., 1997; Khasawneh et al., 2006; Velada et al., 2009; Yamkovenko et al., 2007). It does, however, include important influencing factors of transfer of training according to the dynamic transfer model. Most factors included in the LTSI focus on individual and contextual influencing factors. Therefore, the LCQ was also included as input for our study, because the factors of the LCQ focus on autonomy support, relatedness support and competence support in educational settings (training). The LCQ also has undergone validation studies in various situations and contexts, but not in nursing practice (Bean et al., 2020; Núñez et al., 2012; Williams and Deci, 1996; Yu et al., 2018). As a result of phase 1 the LTSI and LCQ were identified as instruments that met the inclusion criteria. One item was removed in this step, because it did not fit the intended goal of the instrument (Table 2, "*The leaders made us feel like we are good at physical activity*"). This led to a final combined questionnaire of 71 items.

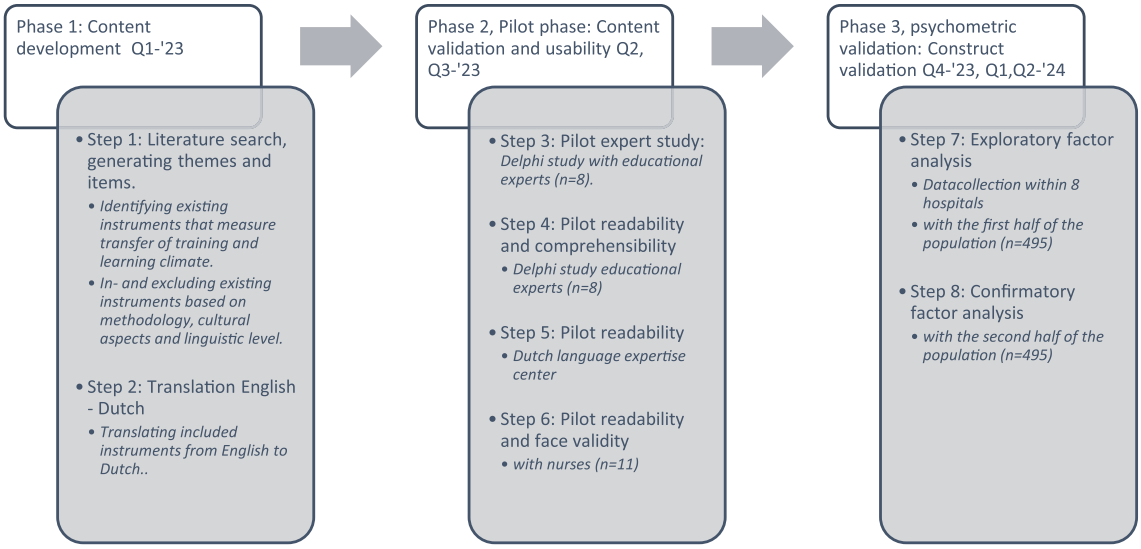

Fig. 1. Flowchart of phases and steps in questionnaire development.

3.2. Phase 2, pilot testing: content validation and usability

Characteristics of the educational experts are shown in Table 1 and results are shown in Table 2 (for this phase, Step 3 I-CVI score and Step 4 mean score on comprehensibility). In total, nine items were deleted in step three demonstrating I-CVI scores <0.50 and one item with I-CVI of 0.50 was also deleted because of sufficient number of items in original construct (autonomy support) and questionable fit in Dutch nursing context. The qualitative feedback of the experts did not result in the development of new items, the feedback solely focussed on the readability of the items. This version was checked for readability and face validity among a diverse group of nurses (newly graduated nurses (n = 1), experienced nurses (n = 7), academic nurses (n = 3)). According to this group of nurses the final version was easy to read and understand, so no further changes were made. This led to the final version of the LTSI and LCQ, combined consisting of 61 items (Table 2, Step 2: LTSI: −4 items, LCQ: −6 items).

3.3. Phase 3: psychometric validation

In total, 1588 nurses filled in the combined instruments (Table 1). For the psychometric validation only complete cases were used (n = 990), because missing data was not at random. Before factor analysis was conducted safety checks for assumptions underpinning factor analysis were checked. All checks were completed successfully (k items: 61, sample size >1000, Ratio 16:1, KMO LTSI: 0.90, KMO LCQ: 0.90, Barthlett's test of spherity for both LTSI and LCQ <0.05, normal distribution for all items). Outliers were not removed, because they were not caused by measurement errors and were not unrepresentative. Outliers were also not transformed, because of normal distribution. To be sure, a method that is robust against outliers was used, namely principal component analysis (PCA). The psychometric validation was conducted for the LTSI and LCQ separately, but also combined.

The data file was split in half and with the first half the PCA was conducted (n = 493, Step 7 in Table 2). The scree plot of the PCA of the LTSI indicated 4 or 11 factors, in addition output showed 11 factors with Eigenvalues >1 and 72 % variance explained. We decided to continue with this number of factors as this best matches the original instrument (16 underlying themes). Then items with low communalities (<0.40) were removed (n = 3). Ideally an item's communality should be ≥0.8, but it is common for communalities to range between 0.40 and 0.70 (Costello and Osborne, 2019). The pattern matrix showed no more low or cross-loadings and let to a final set of the LTSI of 41 items with factor loadings that ranged from 0.46 to 0.92. The scree plot of the PCA of the LCQ demonstrated one strong factor also having one Eigenvalue >1 explaining 71 % of the variance. There were no items with low communalities, resulting in a final set of 17 items with factor loadings that ranged from 0.67 to 0.91. As a result of step seven, the LTSI consisted of 41 items and the LCQ of 17 items, combined 58 items (Step 7, LTSI -3 items, LCQ no items deleted).

The next step was to test the fit of the structure determined by the EFA. The CFA model (Table 2 and Table 3, n = 392) of the LTSI indicated that the 11 factor model fitted well. This led to a final model with adequate fit (range loadings 0.37 to 0.99, Normed X^2 = 1.996, TLI = 0.908, CFI = 0.920, RMSEA = 0.050 [90%CI = 0.047–0.054]). Furthermore, the estimated covariance paths between the factors were all lower than the suggested 0.85 cut-off, indicating discriminant validity. No items were deleted during this step. The resulting CFA model of the LCQ (n = 497) showed also one factor solution. The final model showed a good fit (range loadings 0.64 to 0.94, Normed X^2 = 3.385, TLI = 0.963, CFI = 0.974, RMSEA = 0.069 [90%CI = 0.061–0.078]) with covariance <0.85. No items were deleted during this step.

In the final model the LTSI and LCQ were combined in the CFA (n = 392). The final model showed twelve first order and two second order factors (Table 4). First order factors are operationalized by the items. Second order factors by various first order factors. The combined model is shown in Fig. 2 in the supplementary material. This model shows a good fit (Normed X^2 = 2.014, TLI = 0.900, CFI = 0.907, RMSEA = 0.051 [90%CI = 0.048–0.054]). The correlations between the factors showed variation. Some covariances show stronger relationships - still <0.85 cut-off - for instance between training-personal (0.68), personal-trainers (0.61) and training-trainers (0.83), which indicate a stronger relation between these factors and how they influence each other. The model also shows low covariances in the second order between the factors context-training (−0.05), context-personal (0.01) and context-trainer (0.08). This indicates that context is a strong independent factor in the instrument that is not influenced by the other factors. Further research is needed to explore the relations between these factors. The composite reliability of the first and second order of the combined model shows good, reliable consistency of the items in the factors (first order) and between the first and second order factors (Table 4). The final instrument is available as supplemental material.

4. Discussion

This study provides a significant advancement in the assessment of training transfer in nursing practice through the development and validation of an integrated measure combining the Learning Transfer System Inventory (LTSI) and the Learning Climate Questionnaire (LCQ). This integrated approach offers a more comprehensive tool for assessing the multifaceted nature of factors influencing training transfer in nursing.

The results of this study show that the adapted LTSI and the adapted LCQ are an adequate fit for use in the Dutch nursing hospital context,

Table 1
Characteristics of included hospitals and experts.

Hospital		Expert						
Number	Number of nurses included (n=)	Expert label	Years of working experience (education related)	Type of education (care)	Level of diploma regarding education	Years of experience regarding professional development nurses.	Age (years)	Gender (F = female)
1	65	D	>10	Nursing	Bachelor	> 10	48	F
		F	>10	Nursing	Bachelor	> 10	57	F
2	212	C	5–10	Master of science	Master	> 10	40	F
3	242	E	>10	–	Master	< 5	44	F
4	29	–	–	–	–	–	–	–
5	295	–	–	–	–	–	–	–
6	355	B	<5	–	Master	< 5	48	F
7	56	G	>10	Nursing	Master	> 10	51	F
8	334	A	5–10	Speech therapist	Master	< 5	47	F
–	–	H*	5-10	–	PhD	–	37	F

* Expert H was an expert outside of the RENurse hospitals.

Table 2
Overview of exclusion of items in the different steps.

Item number***	Factors	Items	Step 3: I-CVI	Step 4: Comprehensibility Mean (range)	Step 7: EFA (factor-loading)	Step 8: CFA (factor-loading)	Reason for exclusion
LTSI Q_17_1	Learner readiness	Prior to the training knew how the program was supposed to affect my performance.	0.86	5.0 (1–8)	0.73	0.67	
LTSI Q_17_2	Learner readiness	Before this training, I had a good understanding of how it would fit my job-related development.	0.71	5.1 (1–8)	0.76	0.74	
LTSI Q_17_3	Learner readiness	I knew what to expect from this training before it began.	0.88	7.6 (3–9)	0.73	0.61	
LTSI Q_12_6	Performance self-efficacy	I never doubt my ability to use newly learned skills on the job.	0.88	5.6 (1–8)	0.63	0.99	
LTSI	Performance self-efficacy	I am sure I can overcome obstacles on the job that hinder my use of new skills or knowledge.	0.75	5.9 (4–8)	–	–	EFA < 0.4
LTSI	Performance self-efficacy	At work, I feel very confident using what I learned in training even in the face of difficult or taxing situations.	0.88	6.1 (2–8)	–	–	EFA < 0.4
LTSI	Motivation to transfer	This training will increase my personal productivity.	0.43	–	–	–	I-CVI < 0.5
LTSI Q_12_8	Motivation to transfer	When I leave this training, I can't wait to get back to work to try what I learned.	0.63	6.9 (1–9)	−0.46	0.58	
LTSI Q_12_10	Motivation to transfer	I believe this training will help me do my current job better.	0.75	8 (7–9)	−0.79	0.86	
LTSI Q_12_11	Transfer effort performance expectation	My job performance improves when I use new things that I have learned.	0.75	7.3 (6–9)	−0.88	0.90	
LTSI	Transfer effort performance expectation	The harder I work at learning, the better I do my job.	0.43	–	–	–	I-CVI < 0.5
LTSI Q_12_12	Transfer effort performance expectation	The more training I apply on my job, the better I do my job.	0.86	5.3 (1–8)	−0.84	0.74	
LTSI Q_12_1	Performance-outcome expectation	For the most part, the people who get rewarded around here are the ones that do something to deserve it.	0.50	4.7 (1–8)	−0.79	0.65	
LTSI Q_12_2	Performance-outcome expectation	When I do things to improve my performance, good things happen to me.	0.63	4.7 (1–7)	0.71	0.77	
LTSI	Performance-outcome expectation	My job is ideal for someone who likes to be rewarded when they do something really good.	0.38	–	–	–	I-CVI < 0.5
LTSI Q_13_1	Performance coaching	People often make suggestions about how I can improve my job performance.	1.0	7.1 (4–9)	−0.86	0.83	
LTSI Q_13_2	Performance coaching	I get a lot of advice from others about how to do my job better.	1.0	7.1 (4–9)	−0.87	0.89	
LTSI Q_13_3	Performance coaching	People often tell me things to help me improve my job performance.	1.0	6.4 (4–8)	−0.85	0.84	
LTSI Q_13_4	Supervisor support	My supervisor will meet with me regularly to work on problems I may be having in trying to use this training.	0.50	4.6 (1–6)	0.79	0.81	
LTSI Q_13_5	Supervisor support	My supervisor will meet with me to discuss ways to apply this training on the job.	1.0	7.6 (6–9)	0.88	0.94	
LTSI Q_13_6	Supervisor support	My supervisor will help me set realistic goals for job performance based on my training.	1.0	7.0 (5–8)	0.84	0.79	
LTSI Q_13_7	Supervisor sanction	My supervisor will oppose the use of techniques I learned in this training.	0.63	5.6 (3–7)	0.85	0.76	
LTSI Q_13_8	Supervisor sanction	My supervisor will think I am being less effective when I use the techniques taught in this training.	0.50	4.9 (2–8)	0.83	0.89	
LTSI Q_13_9	Supervisor sanction	My supervisor will probably criticize this training when I get back to the job.	0.63	6.3 (1–9)	0.81	0.76	
LTSI Q_13_10	Peer support	My colleagues will appreciate my using the new skills I learned in this training.	1.0	8.1 (6–10)	−0.88	0.79	
LTSI Q_13_11	Peer support	My colleagues will encourage me to use the skills I have learned in this training.	1.0	8.3 (6–10)	−0.87	0.85	
LTSI Q_13_12	Peer support	At work, my colleagues will expect me to use what I learned in this training.	1.0	8.1 (5–10)	−0.76	0.65	
LTSI Q_13_13	Resistance to change	Experienced employees in my group ridicule others when they use techniques they learn in training.	0.88	6.7 (5–10)	0.58	0.55	
LTSI Q_13_14	Resistance to change	People in my group are not willing to put in the effort to change the way things are done.	0.88	6.9 (1−10)	0.91	0.90	
LTSI Q_13_15	Resistance to change	My workgroup is reluctant to try new ways of doing things.	0.88	8.4 (1–10)	0.88	0.75	
LTSI	Personal outcome þ ve.	Successfully using this training will help me get a salary increase.	0.38	–	–	–	I-CVI < 0.5
LTSI Q_12_13	Personal outcome þ ve.	If I use this training I am more likely to be rewarded.	0.63	6.6 (2–9)	−0.84	0.84	

(*continued on next page*)

Table 2 (*continued*)

Item number***	Factors	Items	Step 3: I-CVI	Step 4: Comprehensibility Mean (range)	Step 7: EFA (factor-loading)	Step 8: CFA (factor-loading)	Reason for exclusion
LTSI Q_12_14	Personal outcome þ ve.	I am likely to receive some recognition if I use my newly learned skills on the job.	1.0	6.3 (4–8)	−0.76	0.75	
LTSI Q_13_16	Personal outcome - ve	Employees in this organization will be penalized for not using what they have learned in this training.	0.63	6 (1–8)	0.89	0.82	
LTSI Q_13_17	Personal outcome - ve	If I do not use new techniques taught in this training I will be reprimanded.	0.60	5.8 (5–7)	0.92	0.92	
LTSI Q_13_18	Personal outcome - ve	If I do not use this training I will be cautioned about it.	0.60	6.2 (5–7)	0.84	0.79	
LTSI Q_12_3	Opportunity to use learning	I will be able to try out this training on my job.	0.86	6.4 (1–10)	0.70	0.87	
LTSI	Opportunity to use learning	The resources needed to use what I learned in this training will be available to me.	0.86	5.9 (1–9)	–	–	EFA <0.4
LTSI Q_12_5	Opportunity to use learning	I will get opportunities to use this training on my job.	0.86	5.7 (1–9)	0.48	0.37	
LTSI Q_12_15	Personal capacity to transfer	I do not have time to try to use this training on my job.	1.0	7.1 (1–9)	−0.82	0.75	
LTSI Q_12_16	Personal capacity to transfer	Trying to use this training will take too much energy away from my other work.	0.88	5.9 (1–8)	−0.82	0.72	
LTSI Q_12_17	Personal capacity to transfer	There is too much happening at work right now for me to try to use this training.	0.88	7.5 (4–9)	−0.49	0.49	
LTSI Q_17_4	Perceived content validity	The instructional aids (equipment, illustrations, etc.) used in this training are very similar to real things I use on the job.	0.88	7.4 (5–9)	0.84	0.74	
LTSI Q_17_5	Perceived content validity	The methods used in this training are very similar to how we do it on the job.	0.88	7.6 (6–9)	0.83	0.72	
LTSI Q_17_6	Perceived content validity	I like the way this training seems so much like my job.	0.63	7.6 (5–9)	0.84	0.75	
LTSI Q_17_7	Transfer design	It is clear to me that the people conducting this training understand how I will use what I learn.	0.88	7 (6–8)	0.80	0.83	
LTSI Q_17_8	Transfer design	The trainer(s) used lot of examples that showed me how I could use my learning on the job.	0.88	7.7 (7–8)	0.77	0.84	
LTSI Q_17_9	Transfer design	The way the trainer(s) taught the material made me feel more confident. I could apply it in my job.	0.71	5.0 (1–7)	0.73	0.87	
LCQ Q_17_10	Autonomy support	I felt that the leaders provided us with choices and options.	0.57	4.7 (1–7)	0.67	0.64	
LCQ Q_17_11	Autonomy support	I felt understood by the leaders.	0.63	7.9 (6–9)	0.88	0.85	
LCQ Q_17_12	Autonomy support	I was able to be open with the leaders during the sessions.	0.50	7.0 (4–8)	0.85	0.88	
LCQ Q_17_13	Autonomy support	The leaders showed confidence in our abilities to do well.	0.75	7.1 (5–8)	0.86	0.87	
LCQ	Autonomy support	I feel that the leaders accepted us.	0.25	–	–	–	I-CVI < 0.5
LCQ Q_17_14	Autonomy support	The leaders helped us to really understand the goals of the session and what we need to do.	0.50	5.4 (2–8)	0.87	0.84	
LCQ Q_17_15	Autonomy support	The leaders encouraged us to ask questions.	0.75	7.9 (6–10)	0.84	0.78	
LCQ Q_17_16	Autonomy support	I feel a lot of trust in our leaders.	0.75	7.4 (5–10)	0.88	0.89	
LCQ Q_17_17	Autonomy support	The leaders answered our questions fully and carefully.	0.75	7.0 (1–9)	0.84	0.85	
LCQ Q_17_18	Autonomy support	The leaders handled our emotions very well.	0.75	7.7 (6–9)	0.80	0.79	
LCQ	Autonomy support	I felt that the leaders care about us as people.	0.13	–	–	–	I-CVI < 0.5
LCQ	Autonomy support	I don't feel very good about the way the leaders talked to us.	0.38	–	–	–	I-CVI < 0.5
LCQ Q_17_19	Autonomy support	The leaders tried to understand how we see things before suggesting new ways to do things.	0.63	6.0 (3–8)	0.83	0.76	
LCQ*	Autonomy support	I felt that I could share my feelings with the leaders.	0.50	–	–	–	x*
LCQ Q_17_20	Autonomy support	The leaders listened to how we would like to do things.	0.75	7.7 (6–9)	0.84	0.77	
LCQ Q_17_21	Competence support	The leaders helped us to improve.	0.86	5.7 (1–9)	0.83	0.83	
LCQ**	Competence support	The leaders made us feel like we are good at physical activity.	–	–	–	–	x**
LCQ	Competence support	I felt that the leaders liked us to do well.	0.38	–	–	–	CVI < 0.5
LCQ Q_17_22	Competence support	The leaders made us feel like we are able to do the activities in the program.	0.71	6.8 (4–9)	0.89	0.94	
LCQ Q_17_23	Relatedness support	The leaders supported us.	0.71	6.5 (4–9)	0.91	0.93	
LCQ Q_17_24	Relatedness support	The leaders encouraged us to work together in practice.	1.0	6.9 (1–8)	0.84	0.82	

(*continued on next page*)

Table 2 (*continued*)

Item number***	Factors	Items	Step 3: I-CVI	Step 4: Comprehensibility Mean (range)	Step 7: EFA (factor-loading)	Step 8: CFA (factor-loading)	Reason for exclusion
LCQ Q_17_25	Relatedness support	The leaders had respect for us.	0.63	7.9 (7–8)	0.85	0.79	
LCQ Q_17_26	Relatedness support	The leaders were interested in us.	0.63	7.9 (6–10)	0.84	0.78	
LCQ	Relatedness support	I felt that the leaders were friendly towards us.	0.38	–	–	–	CVI < 0.5

* LCQ-1-14 was excluded after step 2 because I-CVI of 0.5, sufficient number of items in original construct (autonomy support) and questionable fit in Dutch nursing context.

** This item was removed before step 2, because it did not fit the intended goal of the instrument in development.

*** The item numbers refer to the items in Fig. 2 in supplementary material.

Table 3
Model fit CFA.

Model	Normed X^2	Comparative Fit Index (CFI)	Tucker Lewis Index (TLI)	Root-Mean Squared Residual (SRMR)	Root-Mean Square error of Approximation (RMSEA)	Confidence interval (CI 0.95)
Adapted LTSI	1.996	0.920	0.908	0.0663	0.051	0.047–0.054
LCQ	3.385	0.974	0.963	0.0264	0.069	0.061–0.078
Combined model	2.014	0.907	0.900	0.0882	0.051	0.048–0.054

independently, but also together. Combined, the adapted instruments assess factors influencing transfer of training in nursing practice as an integrated measure, with all constructs from the dynamic transfer model being assessed (personal, contextual, and training/trainer related influencing factors). If used separately, the adapted LTSI can be used to measure the personal and contextual constructs, and to a lesser extent, the training constructs of transfer of training in nursing practice. If the aim is to evaluate the training and trainers solely, the adapted LCQ can be used.

Our study introduces an innovative measurement framework that captures both individual, contextual and training related factors influencing training transfer. Unlike prior instruments that often focused narrowly on specific elements (Machin and Fogarty, 2004; Rouiller and Goldstein, 1993; Thayer and Teachout, 1995) our integrated measure encompasses a broader spectrum, thus providing a holistic view of the transfer process. This comprehensive approach is crucial for accurately identifying and addressing the barriers that nurses face in applying new skills and knowledge in practice.

Our findings align with and extend the existing literature on training transfer. For instance, Bai et al. (2018) developed and validated the Factors Influencing Training Transfer (FITT) in nursing practice in China (Bai et al., 2018). This study identified a five-factor model which included managerial support, hindrances in the organization, validity of training program, organizational and personal facilitators, and personal attitude towards training transfer. Despite important cultural differences, the FITT showed moderate fit in the CFA and had a disproportionate number of items across factors. This disproportionate distribution could potentially limit its generalizability and practical application (Bai et al., 2018). The innovative character of this study is the combination of the LTSI and the LCQ. Together, these instruments measure all influencing factors according to the dynamic transfer model, including personal, contextual, and training/trainer-related factors. The combined use of LTSI and LCQ provides a more holistic understanding of training transfer. The LTSI focuses on individual and contextual factors, while the LCQ emphasizes the training environment and trainer support. This dual approach ensures that all critical aspects influencing training transfer are measured, offering a more detailed and nuanced analysis than other existing instruments (Bean et al., 2020; Blume et al., 2019; Holton Iii et al., 2000).

4.1. Strengths and limitations

The following considerations regarding this study must be discussed. A systematic literature search was conducted to identify instruments that were developed to measure transfer and learning climate in the healthcare context. However, the search was systematic, comprehensive, and validated by experts which ensures that the most relevant and widely-recognized instruments fitting the theoretical model used in this study were included. For the EFA and CFA, only complete cases were used. This resulted in the exclusion of a large sample of cases. However, the number of complete cases was more than sufficient for factor analysis. Incomplete cases can introduce bias and reduce the validity of the factor solutions because missing data can distort the relationships between variables. By using complete cases, we can ensure that the factor analysis accurately reflects the underlying structure of the data. Strengths of this study include the inclusion of a large, heterogeneous nursing population and the robust methods that were used in the method section, including the Consensus-based Standards for the selection of health Measurement INstruments (COSMIN) and Principal Component Analysis (PCA). The large sample size enhances the generalizability of the findings, while the heterogeneity of the sample ensures that the results are applicable across different subgroups within the nursing population. Additionally, using COSMIN standards provides a systematic approach to evaluate the methodological quality of the instruments, ensuring that the results are both reliable and valid. PCA helps in identifying the underlying structure of the data, making it a robust method for exploratory factor analysis. Overall, the decision to use only complete cases, combined with a large and diverse sample and robust analytical methods, strengthens the validity and reliability of the study's findings.

4.2. Implications for practice

The results of this study can have significant implications for nursing practice, particularly in the areas of training, professional development, and organizational policy. The validated instruments, the LTSI and the LCQ, provide comprehensive tools for assessing and enhancing training transfer in nursing practice. Insights gained from these instruments can be used to design and refine nursing training programs by identifying specific factors that facilitate or hinder training transfer of nurses. These findings can inform policy development at both the organizational and broader healthcare system levels, ensuring supportive learning

Table 4
Composite reliability of the first and second order constructs.

Second order	Context (LTSI)					Personal (LTSI)						
Composite reliability, second order	0.629					0.702						
First order	Supervisor/ employer support	Supervisor sanction	Colleagues/ employer reprimands	Coaching colleagues	Resistance to change colleagues	Motivation/ transfer effort performance	Performance/ reward	Performance/ reward	personal capacity to transfer	outcome expectation, use of learning and self-efficacy	Trainer (LCQ)	Training (LTSI)
Composite reliability, first order	0.828	0.845	0.882	0.891	0.785	0.858	0.793	0.810	0.693	0.734	0.970	0.918

environments and adequate resource allocation. By fostering a culture of peer support and collaboration, organizations can create an environment conducive to continuous learning and practical application of new skills. The adapted LTSI and LCQ can facilitate meaningful conversations between nurses, managers, and educational experts, leading to actionable strategies to improve training programs (Hakvoort et al., 2021). Additionally, the development of interactive digital platforms based on these tools could provide real-time feedback and facilitate continuous improvement in training programs. Further research should validate these instruments in diverse nursing settings and explore the relationships between identified factors and clinical outcomes to maximize training program effectiveness. Overall, these validated instruments offer valuable tools for enhancing training transfer in nursing practice, improving patient care, and advancing clinical outcomes.

5. Conclusion

Overall, this study represents a significant advancement in measuring training transfer in nursing practice. The integrated LTSI and LCQ offer a comprehensive and validated tool that addresses individual, contextual and training/trainer factors. This holistic approach is crucial for accurately identifying barriers and facilitators to training transfer, ultimately leading to improved training programs, enhanced clinical competence, and better patient care. Further research and practical applications of these findings can continue to improve nursing education and practice.

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Lysette Hakvoort: Writing – original draft, Visualization, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Jeroen Dikken:** Writing – review & editing, Visualization, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Lê Thuy Dinh Xuan:** Methodology, Conceptualization. **Marieke van der Schaaf:** Writing – review & editing, Supervision, Conceptualization. **Marieke Schuurmans:** Writing – review & editing, Supervision, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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