Development and validation of a measurement scale for nursing students’ readiness to the flipped classroom in Sri Lanka

Punithalingam Youhasan1,2*, Yan Chen1, Mataroria Lyndon1, Marcus A. Henning1

1Centre for Medical and Health Science Education, Faculty of Medical and Health Sciences, The University of Auckland, Auckland, New Zealand;
2Department of Medical Education & Research, Faculty of Health-Care Sciences, Eastern University, Sri Lanka, Batticaloa, Sri Lanka.

* Corresponding email: youhasanp@esn.ac.lk or p.youhasan@auckland.ac.nz

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Abstract

Purpose: It aims to develop and validate a scale to measure nursing students’ readiness to the flipped classroom in Sri Lanka.

Methods: A literature review provided the theoretical framework for developing the Nursing Students’ Readiness for Flipped Classroom (NSR-FC) questionnaire. Five content experts evaluated the NSR-FC, and content validity indices were calculated. Cross-sectional surveys among 355 undergraduate nursing students from 3 state Sri Lankan universities were carried out to assess the psychometric properties of the NSR-FC. Principal component analysis (PCA, n = 265), internal consistency (through Cronbach’s alpha, n = 265), and confirmatory factor analysis (CFA, n = 90) were done for construction validity and reliability test.

Results: There were 37 items included in the NSR-FC for content validation and resulting in an average scale content validity index (S-CVI/AVE) of 0.94. Two items received item level content validity index (I-CVI) less than 0.78. The factor structures of the 35 items were explored through PCA with orthogonal factor rotation culminating in the identification of 5 factors. These factors were classified as technology readiness, environmental readiness, personal readiness, pedagogical readiness, and interpersonal readiness. The NSR-FC also showed an overall acceptable level of internal consistency (Cronbach’s alpha 0.9). The CFA verified a 4-factor model (excluding the interpersonal readiness factor) and 20 items achieved acceptable levels of acceptance (SRMR=0.08, RMSEA=0.08, CFI=0.87 and χ2 /df =1.57).

Conclusion: The NSR-FC, as a four-factor model, is an acceptable measurement scale for nursing students’ readiness to the flipped classroom in terms of its construct validity and reliability.

Keywords: Nursing education; Psychometrics; Reproducibility of results; Statistical factor analysis; Sri Lanka
Introduction

Background/rationale: Contemporary nursing education aims to prioritize student-centred learning, which is perceived as high ordered, flexible, and individualized [1]. Recent technology advancements have accelerated education innovations such as blended learning by providing easy access to information [2, 3]. Blended learning is a novel student-centred pedagogical approach that includes technology-mediated online and face-to-face (F2F) learning [2]. The flipped classroom (FC) is one of the modern blended learning strategies [3]. In FC, teachers use technology and share pre-class learning material to activate low-ordered learning, and students study the material before attending the F2F classroom. Teachers design the F2F classroom as an interactive educational environment by using student-centred teaching strategies for allowing the students to apply or evaluate the learnt concepts [1, 2].

The flipped classroom has emerged into undergraduate nursing education and has been in the spotlight in implementing nursing curricula [2, 3]. With an increasing emphasis on the FC, available empirical evidence on FCs usage and efficacy in nursing education mainly refers to its effects on students’ academic achievements and do not take into account other aspects of educational effectiveness [1, 2]. Thorndike (1932) outlined a law of learning that students’ readiness to learn is an indispensable factor for measuring the degree of success of academic achievement [4]. Flipped classroom readiness can be conceived as a concept which describes the ability of an individual to benefit from blended learning [5]. Moreover, it is asserted that readiness is a level of mental and physical preparedness among learners when taking part in the FC [6]. In addition, assessing students’ readiness is the preliminary step for implementing the FC [3]. However, there is limited research investigating the student’s readiness for FC educational process in the context of nursing education. Therefore, developing a measurement instrument to investigate students’ readiness for FC would be seen as valuable for evaluation and research purposes.

Objectives: This study aimed to develop and validate a tool to measure nursing students’ readiness scale for FC, namely the Nursing Students’ Readiness for Flipped Classroom (NSR-FC). Specifically, content validity, construction validity, and reliability tests were done to validate the measurement scale.

Methods

Ethics statement: The study was approved by the University of Auckland Human Participants Ethics Committee (Reference Number 024079). Participants’ information sheet was provided before administering the anonymized questionnaire. Participants were clearly informed that the voluntary return of the questionnaire to the collection box indicates their consent to participate in the anonymized survey.

Study design: It is the psychometric study to validate the measurement scale based on the experts’ opinion and survey results with the scale.
Participants: Five experts participated in the validity test of the scale. The 265 undergraduate nursing students (in 1st and 2nd academic years) from 3 state universities [Colombo University (n=141), University of Peradeniya (n=73) and Eastern University, Sri Lanka (n=51)] in Sri Lanka participated in the exploratory factor analysis. Ninety different undergraduate (3rd and 4th academic years) nursing students’ responses [University of Peradeniya (n=42) and Eastern University, Sri Lanka (n=48)] were employed in the CFA.

Setting: The cross-sectional study was conducted in two steps. The first step involved the process of development of a scale for measuring the NSR-FC. The second step was to investigate the psychometric properties of the NSR-FC.

Step-1: Developing a scale for measuring nursing students’ readiness for the flipped classroom: The NSR-FC was drafted after reviewing the literature pertinent to learner readiness. The following existing inventories were used to generate items for the NSR-FC: E-Learning Readiness [7]; Online Learning Readiness Scale [6] and ICT literacy scale [8]. However, none of the existing inventories were developed specifically for nursing education. Therefore, 18 items (Q1-3, Q5-6, Q15-17, Q21-24, Q26, Q28-29 and Q33-35) were generated specifically for FC readiness by our research team based on our experience in teaching and learning in clinical and nursing education. Furthermore, 19 items were remodeled from the existing inventories and included in the NSR-FC. As a result, 37 preliminary items were included in the NSR-FC. A 5-point Likert scale, with responses, ranging from 1 (Strongly Disagree) to 5 (Strongly Agree) was used as item anchors (Suppl. 1).

Step-2: Exploring the psychometric property of the NSR-FC:
Content validation of the NSR-FC: Content validation was done to assess the level of representativeness, relevancy, understandability and completeness of the NSR-FC. Five Sri Lankan content experts including 3 senior academics in health profession education and 2 academics in nursing participated and individually evaluated the degree of item significance to the nursing students’ readiness to the engage in FC. The content validity indices (CVI) at the average scale-level (S-CVI/Average) and item-level (I-CVI) were calculated by using descriptive statistics. The I-CVI for each item on the NSR-FC was computed as the number of experts giving a rating of 1 (not relevant) to 4 (highly relevant) divided by the total number of experts who responded to the item. The I-CVI score of 0.78 or higher was assumed as adequate [9]. The S-CVI/Average is the sum of the I-CVIIs divided by the total number of items. The S-CVI/Average score of 0.90 or above was considered as acceptable [9].

Construct validation of the NSR-FC: Exploratory and confirmatory factor analysis were employed in the investigation of construct validation of the NSR-FC. There were 265 undergraduate nursing students participated in the exploratory factor analysis (EFA). The Kaiser–Meyer–Olkin (KMO) and Bartlett’s test
of sphericity were used to test the adequacy of the study’s sample and suitability of orthogonal factor rotation [10]. Principal components analysis was used with Varimax rotation to identify the factors of the NSR-FC items’ that relate to the corresponding variables. A parallel analysis was performed to confirm the extracted factors by comparing eigenvalues obtained from raw data sets and randomly generated parallel dataset [11]. The factors which received eigenvalues higher than those from the corresponding datasets were included for further analysis [11]. The cut-off extraction value of factor loading was determined as 0.4 or above [12].

The degree of model fit was assessed through CFA. Ninety different undergraduate nursing students’ responses were employed in the CFA (Dataset 2). Four goodness-of-fit indices were calculated to estimate the global fit of the NSR-FC: comparative fit index (CFI > 0.90); root mean square error of approximation (RMSEA<0.05 =“Close fit” and RMSEA between 0.05-0.08=“Reasonable fit”); standardized root mean square residual (SRMR ≤0.08) and χ² and its subsequent ratio with degrees of freedom (χ² /df <5) [6, 13].

The internal consistency of the NSR-FC: Internal consistency is commonly used for reporting the degree of reliability of the self-reporting questionnaire. The internal consistency of NSR-FC was measured by computing the Cronbach alpha coefficient. The Cronbach’s alpha score of 0.70 or higher was assumed as acceptable internal consistency which indicates that the observed score variance is reliable when compared with the true score variance [14].

Study size: According to Lynn [15], five content experts were recruited for the content validation. Three-hundred sixty five students participate in the study. Cattell (1978) recommended 3 to 6 samples per variable for conducting EFA [16]. Therefore, we randomly selected 1st and 2nd academic years students [(35*6)<(n=265)] for the EFA and the reliability test. The remaining sample (n=90) were used for the CFA, which was sufficient to produce a good agreement between sample and population solutions (K value = 0.92) [17].

Statistical methods: Descriptive statistics were employed in measuring CVIs by using Microsoft Excel (Microsoft, Redmond, WA, USA). PCA was applied using SPSS ver.26 (IBM Corp., Armonk, NY, USA) to explore the factor structure. Cronbach alpha coefficients were computed using SPSS 26. The CFA goodness-of-fit indices were calculated using AMOS 26 [8, 10].

Results

Content validation

At the item level, 91.9% of the NSR-FC’s items (n=34) had an I-CVI greater than or equal to 0.90. Two items of the NSR-FC (E1 & E2) received I-CVI less than 0.78 namely “I can discipline myself to follow
flipped learning” (I-CVI=0.75) and “I am committed to using flipped learning” (I-CVI=0.45). In addition, reviewers reported that E1 and E2 duplicated existing items, the two items were, thus, excluded from the questionnaire. The S-CVI/AVE of the questionnaire achieved the acceptable level of 0.94 (Suppl. 1).

**Exploratory factor analysis of the NSR-FC**

The NSR-FC was explored using principal component analysis (PCA) to determine the optimal model that best represents the data. The Kaiser–Meyer–Olkin (KMO) value of the NSR-FC is 0.873, suggesting that samples are adequate for the PCA. Bartlett’s test of sphericity further affirmed ($\chi^2 = 4717.18, p < 0.001$) the suitability of the data for PCA with orthogonal factor rotation. The PCA revealed that NSR-FC could be reduced to five factors, namely technology readiness; environmental readiness; personal readiness; pedagogical readiness; interpersonal readiness. Parallel analysis confirmed the 5 factors in the NSR-FC. The percentage variances explained by rotated factor matrices ranged from to $25.42\%$ per factor, with five factors explaining $55.25\%$ of the overall variance. Factor loading after rotation of each item is shown in Table 1 (Dataset 1).

**Table 1**: Results of the principal component analysis with varimax rotation

<table>
<thead>
<tr>
<th>Item</th>
<th>Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Q12</td>
<td>.706</td>
</tr>
<tr>
<td>Q8</td>
<td>.696</td>
</tr>
<tr>
<td>Q11</td>
<td>.695</td>
</tr>
<tr>
<td>Q14</td>
<td>.676</td>
</tr>
<tr>
<td>Q10</td>
<td>.674</td>
</tr>
<tr>
<td>Q13</td>
<td>.664</td>
</tr>
<tr>
<td>Q9</td>
<td>.656</td>
</tr>
<tr>
<td>Q7</td>
<td>.631</td>
</tr>
<tr>
<td>Q6</td>
<td>.550</td>
</tr>
<tr>
<td>Q15</td>
<td>.511</td>
</tr>
<tr>
<td>Q18</td>
<td>.476</td>
</tr>
<tr>
<td>Q16</td>
<td>.476</td>
</tr>
<tr>
<td>Q24</td>
<td>.901</td>
</tr>
<tr>
<td>Q20</td>
<td>.896</td>
</tr>
<tr>
<td>Q25</td>
<td>.885</td>
</tr>
<tr>
<td>Q21</td>
<td>.861</td>
</tr>
<tr>
<td>Q23</td>
<td>.792</td>
</tr>
</tbody>
</table>
Accordingly, technology readiness (factor-1) included 12 items (Q6-16 and Q18). The factor had an accumulated eigenvalue of 8.89 and accounted for 25.42% of the total variance. The environmental readiness (factor-2) comprised 5 items (Q20-21 and Q23-25) and an accumulated eigenvalue of 4.38 and accounted for 12.51% of the total variance. The personal readiness (factor-3) contained 6 items (Q1-4, Q17 and Q19). The factor had an accumulated eigenvalue of 2.81, which accounted for 8.02% of the total variance. The pedagogical readiness (factor-4) encompassed 7 items (Q22, Q26-29 and Q34-35) and an accumulated eigenvalue of 1.75, which accounted for 5.01% of the total variance. The interpersonal readiness (factor-5) included 4 items (Q30-33) and had an accumulated eigenvalue of 1.50 accounting for 4.29% of the total variance. Item Q5 obtained the factor extraction value of 0.25, which was deemed as low and thus excluded from the NSR-FC.
Internal consistency of the NSR-FC

Cronbach’s alpha of the NSR-FC’s factors ranged from 0.76 to 0.93 and for the scale as a whole was 0.90, indicating excellent reliability. The intraclass correlation coefficient (ICC) for the FCRQ’s factors was satisfactory (ICC ranged from 0.76 to 0.92; $p < 0.01$) for each subscale and overall ICC was 0.90 exhibit the acceptable level of reliability, the data are presented in Table 2 (Dataset 1).

Table 2: Results of internal consistency

<table>
<thead>
<tr>
<th>Factor No.</th>
<th>Factor Name</th>
<th>Items</th>
<th>Cronbach’s alpha</th>
<th>ICC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Technology Readiness</td>
<td>12</td>
<td>0.88</td>
<td>0.87</td>
</tr>
<tr>
<td>2</td>
<td>Environmental Readiness</td>
<td>5</td>
<td>0.93</td>
<td>0.92</td>
</tr>
<tr>
<td>3</td>
<td>Personal Readiness</td>
<td>6</td>
<td>0.76</td>
<td>0.76</td>
</tr>
<tr>
<td>4</td>
<td>Pedagogical Readiness</td>
<td>7</td>
<td>0.81</td>
<td>0.81</td>
</tr>
<tr>
<td>5</td>
<td>Interpersonal Readiness</td>
<td>4</td>
<td>0.78</td>
<td>0.77</td>
</tr>
<tr>
<td>Overall</td>
<td></td>
<td>34</td>
<td>0.90</td>
<td>0.90</td>
</tr>
</tbody>
</table>

$^a$= P-value < 0.01

Results of confirmatory factor of the NSR-FC

Model 1 of the CFA denotes the baseline model, with 34 items as identified by the PCA. In reference to model 1, the goodness-of-fit indices did not achieve the acceptable level (Except $\chi^2 / df$ value). Therefore, model 2 was created by excluding five items (Q7, 10, 16, 22 & 33) which reported loading values less than 0.4; however, the goodness-of-fit values of model 2 were still below the cut-off level (Table 3, Dataset 2).

Table 3: Goodness-of-fit indices from CFA to test the suitability of the NSR-FC

<table>
<thead>
<tr>
<th>Model</th>
<th>Model Description</th>
<th>SRMR</th>
<th>CFI</th>
<th>RMSEA</th>
<th>$\chi^2 / df$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Model with 34 items (After excluding the item 5)</td>
<td>0.11</td>
<td>0.70</td>
<td>0.09</td>
<td>1.67</td>
</tr>
<tr>
<td>2</td>
<td>Model with item which obtained loading value &gt;0.4</td>
<td>0.10</td>
<td>0.77</td>
<td>0.09</td>
<td>1.68</td>
</tr>
<tr>
<td>3</td>
<td>Model with four factors (After excluded factor 5)</td>
<td>0.08</td>
<td>0.87</td>
<td>0.08</td>
<td>1.57</td>
</tr>
</tbody>
</table>

In addition, all items in factor 5 did not obtained an acceptable loading value. Therefore, it was decided to exclude the factor 5 in model 3. Model 3 (Fig. 1) was found as the best fitted model in the current study. According to SRMR and an adjunct discrepancy-based fit index ($\chi^2 / df$), model-3 achieved the acceptable
level of fit (SRMR=0.08 and χ²/df =1.57). In reference to RMSEA, the model 3 obtained reasonable fit (RMSEA=0.08). In terms of CFI (0.87), the model 3 met the cut-off level (Table-3).

Discussion

Interpretation: Student readiness is recognized as a valuable factor to determine pedagogical effectiveness [4]. Therefore, the present study investigated the development and psychometric properties of a scale used for measuring nursing student’s readiness for the flipped classroom. More specifically, the study explored the construct validity and reliability of the NSR-FC.

The method used to construct the NSR-FC was similar to the procedure used for the development of student readiness scale in other disciplines, which includes proposing constructs, item generation, analysis of the content, item reduction and validation of the newly developed instrument [6, 7]. The PCA revealed a potential 5-factor structure of the NSR-FC. However, the CFA was only able to confirm a 4-factor model as determined by an inspection of the fit indices. The four factors that best fitted the data with respect to the NSR-FC, included technology readiness; environmental readiness, personal readiness and pedagogical readiness.

The best fitted 4 factors of the NSR-FC were comparable with the existing inventory which is being used for measuring student’s readiness for blended learning in school level education. Technology-readiness has been a common subset identified as technology self-efficacy in many other studies [6, 18]. Technology-readiness denotes an individual’s willingness to leverage novel technologies in carrying out tasks [19]. Items relating to the environmental readiness in the NSR-FC were seen to load together as a technological factor in the E-Learning Readiness scale [7]. Personal readiness was recognized as a factor in the NSR-FC. Since FC is a student-centered pedagogical approach, students take a significant role in the teaching-learning activities. Therefore, it is necessary for estimating students’ individual willingness to engage in FC. The personal readiness was outlined as “Learner control”, with some variation in the Online Learning Readiness Scale [6]. The pedagogical readiness in the NSR-FC describes students’ willingness to embrace learning content through FC pedagogy. Few items in the pedagogical readiness were correlated with the subscale of “online communication self-efficacy” in the online learning readiness scale [6] and “content factor” in the E-Learning Readiness [7].

In terms of reliability assessment, the NSR-FC obtained acceptable internal consistency. All four factors of the NSR-FC generated Cronbach alpha and ICC levels of greater than 0.7, confirming internal consistency within the domains and the ability of the NSR-FC to generate reproducible results. Therefore, the 4-factor model of NSR-FC is a valid and reliable tool than can be used for measuring students’ readiness.

Limitation/generalizability: The instrument can, thus, be used by nursing educators and curriculum planners for evaluating the effectiveness of FC pedagogy. However, the results of the factor analysis could be sample-specific, and generalizability of these results are subject to the similarity of the sample.
Since the study was conducted in Sri Lanka, the NSR-FC could be used to assess nursing students’ readiness for FC in the context of South Asia. Moreover, the CFI value of the NSR-FC did not exceed the acceptable level. This may due to the limited sample size and this is recognized as a limitation of the study. Thus, future research would be encouraged to perform a CFA of the NSR-FC with a larger sample size. Lastly, the study was conducted through a self-reported questionnaire survey, which may create reporting biases such as social desirability [20]. It is recommended that qualitative research will likely be instructive in terms of uncovering a greater understanding behind the phenomena of nursing students’ readiness for FC.

**Conclusion:** These findings indicate that the NSR-FC is an acceptable instrument for measuring nursing student readiness for FC in reference to its construct validity and reliability within the Sri Lankan nursing education context. The four readiness subscales were found to be technology readiness, environmental readiness, personal readiness and pedagogical readiness. It is believed that this finding may provide a good platform and frame of reference for nursing curriculum researchers and educational designers regarding the necessity for assessing students’ readiness for gaining actual educational achievement through FC.

**ORCID**
Punithalingam Youhasan: https://orcid.org/0000-0002-3435-7839
Yan Chen: https://orcid.org/0000-0002-1665-9294
Mataroria Lyndon: https://orcid.org/0000-0002-5621-4839
Marcus A. Henning: https://orcid.org/0000-0002-1135-3464

**Authors’ contributions**
Conceptualization: PY, YC, ML, MAH.
Data curation: PY.
Formal analysis: PY, MAH.
Funding acquisition: Not Applicable.
Methodology: PY, YC, ML, MAH.
Project administration: PY.
Visualization: Not Applicable.
Writing – original draft: PY.
Writing – review & editing: PY, YC, ML, MAH.

**Conflict of interest**
No potential conflict of interest relevant to this article was reported.
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Data availability
Data files are available from Harvard Dataverse.
Dataset 1. Two-hundred sixty-five students’ responses to the measurement scale for nursing students’ readiness to the flipped classroom for exploratory factor analysis and reliability test
Dataset 2. Ninety students’ responses to the measurement scale for nursing students’ readiness to the flipped classroom for confirmatory factor analysis

Acknowledgments
None

Supplementary materials
Supplement 1. Results of the content validation of the measurement scale for nursing students’ readiness to the flipped classroom
Supplement 12 Audio recording of the abstract.

Appendix
None

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Legends for figures
Fig. 1: Model 3 with factor loadings for the 20-item in the Nursing Students’ Readiness for Flipped Classroom (NSR-FC)