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Exploratory Factor Analysis of Online Teaching Effectiveness in Nursing Education

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ABSTRACT

The rapid growth of online education has necessitated an in-depth investigation into the factors influencing teaching effectiveness in online learning environments. This study aims to identify and examine the key factors contributing to the online teaching effectiveness of nurse instructors through Exploratory Factor Analysis (EFA) and develop a tool to measure the Online Teaching Effectiveness (OTE) of nursing instructors. Preliminary item statements were developed based on a thorough review of relevant literature, resulting in a 49-item scale. A multidisciplinary panel member then validated the content, reducing it to a 48-item Content Validated item statement. Pilot testing with 596 third-level students from the College of Nursing at NEUST led to a final set of 41 items. The EFA in this study was carried out using a single random subsample of 410 Level IV Bachelor of Science in Nursing (BSN) student nurses from Higher Education Institutions across Luzon, Visayas, and Mindanao in the Philippines. All respondents were enrolled in the BSN program and participated in online education. This sample size adhered to the "10-times rule," ensuring at least ten observations per variable for the Exploratory Factor Analysis (EFA). Using the five-step Exploratory Factor Analysis Protocol (preliminary analysis for evaluation of data suitability for EFA, factor extraction, factor retention, and factor rotation) determines the data suitability for Exploratory Factor Analysis. This process, employing Varimax and Kaiser Normalization, revealed a 3-factor structure: (1) Active Learning, (2) Instructor-Learner Connection, and (3) Modern Teaching, comprising 28-item statements. Together, these factors explained 75.221% of the variance. The 75.221% variance explained by the three factors is a relatively high value, suggesting that the model provides a good fit to the data. The findings can guide instructional practices by highlighting the importance of active learning, strong instructor-student relationships, and the use of modern teaching techniques. By understanding these factors, educators can make informed decisions to improve their instructional practices and enhance student success. While these findings shed light on online teaching effectiveness in nursing education, further psychometric validation is needed to refine the instrument. Future research should explore its applicability across different samples and disciplines to better evaluate online teaching quality.

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1. INTRODUCTION

Education is undergoing an explosive and unstoppable transformation that embraces the digital age. In the last two decades, there has been a significant increase in the number of higher education institutions offering online courses [1]. Currently, the highest priority of the education sector is utilizing technological advancement to prepare students for the evolving workforce and help them adopt the globalized, competitive nature of the 21st century [2]. Online education has gained relevance in higher education as it offers a platform to develop 21st-century skills among students [3]. The effectiveness of online education is primarily dependent on the instructor's ability to teach effectively in an online environment [4]. While many theories and ideas about online teaching evaluation exist, only some tools can swiftly and precisely determine and evaluate teacher effectiveness [5]. The study of how face-to-face students (F2F) evaluate teaching effectiveness has accumulated for the past 90 years.

While there are approximately 2,000 references to student rating scales used in F2F courses, there has been a lack of focus on the rating scales and other measures used to evaluate faculty who teach online courses. Many institutions use evaluation tools designed for classroom-based learning experiences to evaluate online courses, rather than developing and testing appropriate new evaluation questionnaires. Instead of developing and testing appropriate new evaluation questionnaires, these existing tools are used verbatim or slightly modified [6]. Evaluation procedure guidelines and parameters should be renewed and updated to get quality outcomes after some time [7]. The structured evaluation of online courses and teachers is very lacking due to the enormous rise of online education [8]. The claim that reliability and validity data are inadequate and that there is a dearth of research and suitable instruments for evaluating effectiveness of online teaching [9].

In response to these concerns, the primary goal of the present study was to develop an instrument of student rating on online teaching effectiveness for nurse instructors derived from the sound Exploratory Factor Analysis (EFA) that can serve as an important step in meeting the increasing prevalence of online nursing education and establishing good online teaching effectiveness practices in a future design.

2. RESEARCH METHOD

Research Design

This quantitative study adopts an Exploratory Factor Analysis approach to develop a tool to evaluate online teaching effectiveness of nurse instructors.

Sample and Setting

All 410 participants in this study are in Level IV and are currently pursuing a Bachelor of Science in Nursing (BSN) degree. They are exclusively engaged in online education, with 100% of them being exposed to this mode of learning. These participants were drawn from Higher Education Institutions (HEIs) across various major islands of the Philippines, including Luzon, Visayas, and Mindanao, ensuring representation from diverse geographical regions.

Instrument

The development of the instrument followed a structured process consisting of three phases, as illustrated in **Figure 1**. In the initial phase, a systematic literature review was conducted to gather relevant information. This review yielded a total of 49 items, which formed the initial set of items for the instrument. Subsequently, in the second phase, a multidisciplinary panel evaluated these items to ensure their content validity. The panel members assessed and refined the items, resulting in a final set of 48 content-validated item statements. In the third phase, these 48 items were pilot-tested, resulting in the generation of a refined set of 41 items. These items were then subjected to Exploratory Factor Analysis (EFA) to explore their underlying factors influencing teaching effectiveness in online learning environments.

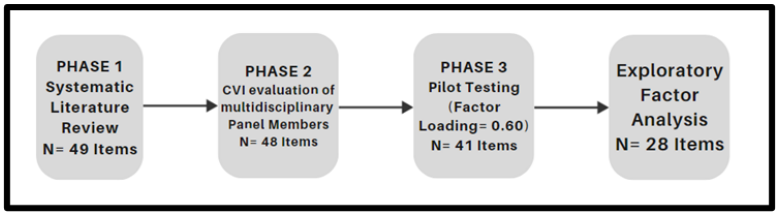

Figure 1. Stages of the Development of Item Statement

Data Collection

A letter of request for institutional participation was sent to the Advisers, Head, and administrative offices via electronic mail. The concerned were asked to disseminate the survey link to the students for inclusion in the study. Upon accepting the agreement, participants were directed to complete and submit the survey. Additionally, the

respondents were recruited via mass emails or by sending the survey website link to student leaders and nursing student organizations, clinical instructors, and nursing review center agencies interacting with the target group. Online forums, social networking sites such as Facebook, and email contacts were also utilized to send website links for questionnaires. The respondents were asked to answer the questions from the provided link. Repeated emails and follow-ups are then used to increase response rates.

Data Analysis

The EFA in this study was carried out using a single random subsample of student nurses and in accordance with the four-step Exploratory Factor Analysis Protocol (preliminary analysis for evaluation of data suitability for EFA), factor extraction, factor retention, and factor rotation.

Preliminary Analysis.

Bartlett's Test of Sphericity and *Kaiser-Meyer-Olkin Test* are the two preliminary test analyses that were used to determine whether the data that were collected for EFA analysis were adequate.

Bartlett's Test of Sphericity. The purpose of the test was to determine if the correlations between the items were significant enough for EFA. Bartlett's Test of Sphericity should achieve a statistical significance of less than.050 (Field, 2013) in order for factor analysis to be considered feasible.

Kaiser-Meyer-Olkin Test (KMO). The sampling adequacy can be measured by examining the KMO. The KMO should be above the acceptable threshold of 0.50 [10].

Factor Extraction.

The Statistical Package for Social Sciences (SPSS) software's default method for factor extraction, Principal Components Analysis (PCA), was preferably used because it is one of the methods for data reduction that is appropriate for factor analysis. The PCA is helpful when the researcher initially developed an instrument with a large number of items and is interested in reducing the number of items.

Factor Retention.

The number of factors retained in this study was based on Kaiser's criteria or eigenvalue greater than the 1.0 rule. Kaiser's rule uses the rationale that there are as many reliable components as there are eigenvalues greater than one.

Factor Rotation. The Varimax with Kaiser Normalization was used in this study that created a solution in which the factors are orthogonal or uncorrelated with one another.

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Statistical Treatment

This study secured the assistance and expertise of the Data Analytics Center of NEUST during the statistical treatment. To prevent the identification of individual responses, the data is downloaded in aggregate form using the Excel spreadsheet application. The Statistical Package for Social Sciences (SPSS) version 27 was used for both data entry and analysis of all quantitative information.

Ethical Consideration

The Holy Angel University Institutional Review Board ethically reviewed and cleared this study under Protocol Number: 2022-071-ZBCATABONADEVELOPMENT&VALIDATIONofNSEOTE.

3. RESULT AND DISCUSSIONS

The findings of this review underscore the importance of adopting a multifaceted approach to online teaching. The articles were subjected to thematic analysis to identify recurring patterns and group them into cohesive themes. Three primary themes emerged from the analysis, the thematic map of OTE (**Figure 2**) enabled the researcher to generate item statements for OTE.

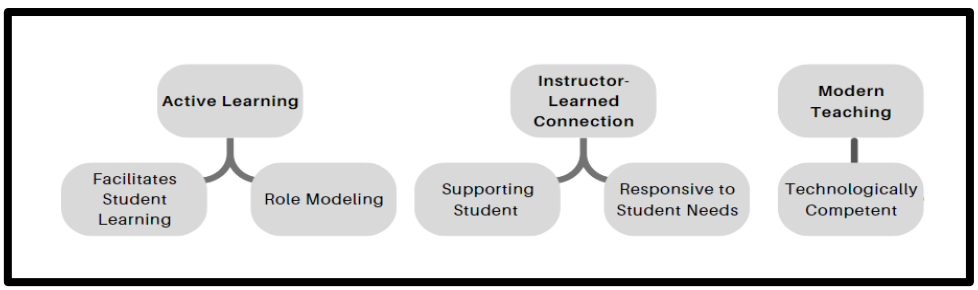

Figure 2. Thematic Map of Online Teaching Effectiveness

The thematic analysis of the reports led to the synthesis of 49-item statements sourced from reputable journals. These items were subjected to Content Validation through the Modified Delphi Technique. Through this process, minor revisions were made to some items while ensuring that the appropriate ones were retained for subsequent

analysis. Following the Content Validation process, the 48-item scale demonstrated strong content validity, meeting the requirements using both the S-CVI/UA approach (1.00) and the S-CVI/Ave approach (1.00). This indicates a high level of agreement among the panel members regarding the relevance and appropriateness of the items for assessing online teaching effectiveness.

A pilot study is performed to analyze the feasibility before the main study. Pilot testing in this study reflects the respondent's viewpoint and that items are suitable, complete, and applicable to their condition. The use of feedback and statistical analysis subsequently reduced the number of items in the survey to a manageable amount. The rotated component matrix, which was pilot-tested and resulted in a manageable number of item statements for the questionnaire, is shown in **Table 1**.

Table 1. Rotated Component Matrixa of Pilot Testing

Item #	Component		
	1	2	3
Q1	0.672	0.457	0.483
Q2	0.665	0.493	0.493
Q3	0.759	0.428	0.39
Q4	0.659	0.512	0.486
Q5	0.665	0.507	0.483
Q6	0.703	0.498	0.431
Q7	0.651	0.523	0.488
Q8	0.663	0.522	0.464
Q9	0.731	0.445	0.428
Q10	0.63	0.544	0.48
Q13	0.539	0.535	0.607
Q14	0.526	0.532	0.604
Q15	0.643	0.417	0.562
Q16	0.501	0.533	0.631
Q18	0.53	0.519	0.624
Q19	0.598	0.417	0.613
Q20	0.569	0.491	0.61
Q21	0.499	0.538	0.647
Item #	**Component**		
	1	**2**	**3**
Q22	0.549	0.517	0.613
Q23	0.52	0.544	0.615
Q24	0.514	0.543	0.633
Q25	0.517	0.532	0.629
Q26	0.521	0.546	0.611
Q28	0.497	0.607	0.58
Q30	0.489	0.622	0.568
Q32	0.521	0.621	0.543
Q34	0.499	0.635	0.54
Q35	0.549	0.641	0.48
Q36	0.53	0.619	0.529
Q37	0.566	0.63	0.485
Q38	0.558	0.623	0.482
Q39	0.565	0.664	0.418
Q40	0.551	0.65	0.482
Q41	0.584	0.635	0.451
Q42	0.49	0.678	0.501
Q43	0.588	0.625	0.42
Q44	0.497	0.637	0.539
Q45	0.554	0.63	0.475
Q46	0.528	0.633	0.519
Q47	0.513	0.644	0.523
Q48	0.49	0.663	0.528

Table 1 presents the components, the items falling under each component, and the factor loading for each item. In accordance with [12], items with factor loadings below 0.6 were suppressed and excluded from the study instruments. As a result, seven items (11, 12, 17, 27, 29, 31, and 33) with low factor loadings were deleted from the 48-item OTE following content validation. This reduction resulted in a total of 41 item statements at this stage of tool development.

Through the EFA procedure, the number and nature of the components or dimensions underlying the present OTE instrument were identified. Factor 1 comprised eleven final item statements, while Factor 2 included eighteen item statements, and Factor 3 contained twelve item statements. These components represent the key dimensions that contribute to the overall assessment of online teaching effectiveness within the nursing education context.

Preliminary Analysis.

The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and the Bartlett test of sphericity were examined to determine the appropriateness of FA. Table 2 includes the computed values for the KMO statistic and the significance level of Bartlett's test. These results help determine the overall suitability and appropriateness of the dataset for conducting factor analysis.

Table 2. Kaiser-Meyer-Olkin and Bartlett's Test Result

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		**.985**
Bartlett's Test of Sphericity	Approx. Chi-Square	20245.105
	df	820
	Sig.	.000

The EFA obtained a KMO value of .985, as shown in Table 2 The KMO value reflects the sampling adequacy that exceeds the acceptable threshold of 0.50. Bartlett's test returned a significance value of .000 and confirmed the significance of the analysis.

Factor Extraction.

The PCA and Kaiser's criteria or eigenvalue greater than the 1.0 rule were implemented for the factor extraction of OTE. Table 3 provides information about the amount of variance explained by each extracted factor or component.

Table 3. Total Variance Table

Compo-nent	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	28.392	69.249	69.249	28.392	69.249	69.249	12.658	30.873	30.873
2	1.352	3.299	72.548	1.352	3.299	72.548	9.413	22.959	53.832
3	1.096	2.673	75.221	1.096	2.673	75.221	8.77	21.389	75.221

Extraction Method: Principal Component Analysis.

Note. Truncated to show only the 3 extracted factors

Using EFA reduces items with low factor loadings and similar meanings to the other items. The extraction method used in this research is the principal component analysis which results in the four-rotation factor analysis. The requirement for identifying the number of components or factors stated by selected variables is the presence of eigenvalues of more than 1. Table 3 shows that for the 1st component, the value is 28.392 > 1, the 2nd component is 1.352 > 1, and the 3rd component is 1.096 > 1. Thus, the stated set of 41 variables with 410 observations represents three components. Further, the extracted sum of squared holding % of variance depicts that the first factor accounts for 69.249% of the variance features from the stated observations, the second 3.299%, and the third 2.673% with a total % of the variance of 75.221%. Thus, three (3) components are effective enough in representing all the characteristics or components highlighted by the stated 41 variables.

Table 4 shows the final rotation for the elimination of the items with low-factor loading and inter-factor convergence using Varimax Rotation. An item having factor loadings below 0.6 were deleted. The first rotation eliminated 10 items Q5, Q4, Q2, Q10, Q22, Q46, Q19, Q28, Q42, Q47. The second rotation eliminated two (2) items, Q38 and Q6. The third rotation eliminated one (1) item Q34, which loads into two of the same factors. No item statement is eliminated in the fifth-factor loading. As shown in Table 5, the factor loading value of 0.60 or higher is retained and thus considered very strong.

Table 4. Rotated Component Matrix a

Item No.	Component		
	1	2	3
Q30	0.789		
Q16	0.782		
Q28	0.753		
Q21	0.751		
Q14	0.727		
Q23	0.724		
Q44	0.719		
Q8	0.716		
Q7	0.709		
Q26	0.701		
Q32	0.690		
Q13	0.690		
Q24	0.680		
Q48	0.662		
Q1	0.640		
Q45		0.774	
Q43		0.754	
Q15		0.715	
Q3		0.681	
Q20		0.680	
Q9		0.668	
Q18		0.664	
Q39			0.758
Q37			0.724
Q41			0.690
Q35			0.689
Q36			0.678
Q40			0.664
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.a			
a. Rotation converged in 7 iterations.			

Table 4 shows the 28-item OTE tool as the product of EFA. These factors were divided into three components, namely Component 1: Active learning. Active Learning (AL) is the item statement that highlights a more involved role of the instructor that goes within, and beyond the course, design, and delivery; (2) Instructor-Learner Connection (ILC) the item statements that express concern and support to students and being responsive to student's needs by providing feedback; and (3) Modern Teaching (MT) The item statements are associated with technological competence in online teaching.

4. CONCLUSIONS

The EFA of OTE involved a multi-step process, including a systematic literature review, content validation and pilot testing and in accordance with the five-step Exploratory Factor Analysis Protocol (preliminary analysis for evaluation of data suitability for EFA), factor extraction, factor retention, and factor rotation.

The panel members used a quality assessment process to evaluate the studies included in the systematic literature review. Based on this evaluation, the researchers determined that articles had passed the quality assessment and were deemed to be of sufficient quality to be included in the review. Additionally, there was an 83% inter-rater agreement among the reviewers, indicating that the quality assessment process was consistent and reliable.

The pilot-tested rotated component matrix was used to analyze the data and reduce the number of items in the questionnaire. The tool initially had 48 items, but seven items were deleted due to low factor loading during the pilot study. Deleting these items reduced the number of items to 41 at this stage of tool development.

EFA of the Scale (Principal Component Factor) was used to evaluate the factor structure and then trailed by varimax rotation. The suitability of data for the execution of EFA was evaluated by the KMO test and Bartlett's test of Sphericity. The KMO test's value is 0.985 (acceptable limits = value greater than 0.50). Bartlett's test of Sphericity (Chi-square: .000, $p < 0.001$) was significant, proving the validity of factor analysis and that data was fit for reduction.

EFA was completed on 28 items. Three factors have an eigenvalue higher than 1. The eigenvalues for all the factors are 28.392, 1.352, and 1.096. The combination of Varimax and Kaiser Normalization creates a solution in which the factors are orthogonal or uncorrelated with one another. A factor loading value of 0.60 or higher is considered strong and retained. The total variance definite by each factor was 69.249%, 3.299%, and 2.673%. These factors altogether described 75.221% of the variance, and these factors were provided names as per their characteristics of loaded items on the similar factor. These factors were divided into three components, namely (1) Active Learning, (2) Instructor-Learner Connection, and (3) Modern Teaching.

The findings of this study suggest that the EFA of OTE tool holds promise for assessing online teaching effectiveness within the nursing education context. However, further validation and refinement are recommended to enhance its reliability and validity. Future research could focus on conducting confirmatory factor analysis and test-retest reliability to strengthen the robustness of the EFA's initial results.

It is essential to recognize that the OTE tool is tailored specifically to the nursing discipline, and its applicability to other disciplines may vary. Further research is needed to replicate the findings of this study and explore the utility of the instrument in evaluating online teaching effectiveness across different disciplines. Additionally, efforts should be made to refine the instrument to ensure its relevance and validity in diverse educational contexts.

The study showed evidence of 28-item statements in a 3-factor model with acceptable psychometric qualities. The SEM analysis also supported the unidimensionality of each factor recommended by the EFA.

The researcher believes this study makes significant contributions to the literature and can be a pivot line for evaluating online teaching effectiveness, primarily if published, circulated, and utilized.

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