Original Article   ∂Open Access

Psychometric validation of Filipino versions of the survey of attitudes toward statistics and attitudes toward research for nursing students

Joseph U. Almazan[1] , Fritz Gerald V. Jabonete[2]* , Cris S. Adolfo[3] , Abdulrhman S. B. Albougami[3] , Jose Arnold Tariga[4] , and Jonas Preposi Cruz[1]

[1] Department of Medicine, School of Medicine, Nazarbayev University, Astana, Kazakhstan

[2] College of Allied Health, Nursing Department, National University, Manila, Philippines

[3] Department of Nursing, College of Applied Medical Sciences, Majmaah University, Majmaah, Saudi Arabia

[4] Director of Clinical Education and Development, Insight Global Health, Boston, Massachusetts, United States

*Correspondence: Fritz Gerald V. Jabonete. Address: College of Allied Health, Nursing Department, National University, Manila, Philippines. E-mail: fvjabonete@national-u.edu.ph

ABSTRACT

Introduction: Despite the recognized importance of assessing nursing students' attitudes toward statistics and research, no validated instruments exist specifically for the Filipino context. This study aimed to evaluate the psychometric properties of the Filipino adaptations of the Survey of Attitudes toward Statistics (SATS-F) and Attitudes toward Research (ATR-F) scales.

Methods: A quantitative cross-sectional survey design, using convenience sampling, was employed to collect data from August to October 2022. Participants were Filipino nursing students taking nursing research and statistics courses who were at least 18 years old. Participants with >10% incomplete data on any instrument were excluded.

Results: Descriptive statistics showed mean scores ranging from 4.45 to 6.10 for ATR-F items and 2.88 to 5.55 for SATS-F items. A strong content validity was demonstrated, with S-CVI/Ave values of 0.94 for ATR-F and 0.98 for SATS-F. Principal Component Analysis (PCA) showed 75.3% of the cumulative explained variance for ATR-F and 61.9% for SATS-F. Pearson correlation analysis further supported construct validity, revealing a significant positive relationship ($r = 0.50$, $p < 0.001$) between ATR-F and SATS-F, which indicates a strong association between nursing students' attitudes toward research and statistics. Internal consistency reliability was established, with Cronbach's alpha coefficients of 0.87 for ATR-F and 0.90 for SATS-F.

Conclusions: SATS-F and ATR-F possess sound psychometric properties, rendering them reliable tools for assessing Filipino nursing students' attitudes toward statistics and research. Educators and researchers can use these culturally adapted and validated instruments to develop targeted interventions to enhance nursing students' preparedness for research-informed practice.

Keywords: attitudes toward research, nursing, psychometrics, statistics

Introduction

Integrating research and statistical analysis is crucial for evidence-based nursing practice, enhancing patient outcomes (Connor *et al.,* 2023). Undergraduate nursing programs require students to take research (Padagas and Hajan, 2020) and statistics courses (Chiesi & Primi, 2009), providing critical knowledge and skills for quantitative research application. However, nursing students consistently report research and statistics as challenging subjects, triggering anxiety, fear, and ambivalence.

Previous research has emphasized the importance of understanding attitudes to gain insight into student achievement. The concept of attitude has captured the interest of behavioral and social scientists since 1935. Eagly and Chaiken (2007) defined attitude as a psychological inclination expressed through evaluating a

specific entity with varying degrees of favor or disfavor. Furthermore, Ajzen and Fishbein (2000) described attitude as an individual's favorability or unfavorability toward a psychological object. Being easier to measure than behavior, attitude is frequently used to comprehend and sometimes forecast people's responses to experiences, objects, or phenomena, and assess their influence on behavior (Eagly & Chaiken, 2007).

Attitude is a critical factor in influencing students' participation and performance. Rind (2020) defines attitudes towards research as individuals' perceptions, beliefs, and emotional reactions about undertaking research tasks. Attitudes may differ from person to person and are shaped by one's experiences, level of education, culture, and the environment in which research is conducted. Positive attitudes toward research are recognized by promoting advancing knowledge, improving its practice application, and guiding choice in evidence-based decision-making (Khan et al., 2021). Meanwhile, negative attitudes toward research may stem from various factors. Some individuals may interpret research as time-consuming and irrelevant to their practices (Kakupa and Xue, 2019). Others may need more research skills or may have limited exposure to research during their educational experiences (Khan et al., 2021). Negative attitudes may also arise from a lack of understanding about the practical significance of research to real-world practice or the research belief that it is difficult to access or only for academics (Padagas & Hajan, 2020).

It is critical to foster positive attitudes toward research among nursing students and healthcare professionals to propel evidence-based practice, enhance patient care, and drive future innovations. In this undertaking, some scales are available to measure attitudes toward research; one is the Attitudes Toward Research (ATR) Scale, which evaluates individuals' perceptions and attitudes toward research activities and their willingness to conduct research (Papanastasiou, 2014). The ATR Scale is widely recognized and adapted into several versions catering to specific cultural contexts and educational settings. Examples include the Italian version (Chiesi & Primi, 2009), the Russian version (Khavenson et al., 2012), the Chinese version (Kakupa and Xue, 2019), the Cypriot version (Papanastasiou, 2014), and the Vietnamese version (Tran-Chi, 2019).

As with attitudes toward research, cultivating a positive outlook on statistics is also crucial in equipping students with the necessary skills to effectively comprehend statistical methods in their research endeavors (Sin & Rosli, 2020). According to Tempelaar, Schim Van Der Loeff, and Gijselaers (2007) and Schau et al. (1995), attitude toward statistics refers to an individual's perspective, emotional responses, and predispositions regarding statistics and its practical applications. It comprises a set of perceptions and attitudes that determine how individuals approach, understand, and utilize statistical concepts and methodologies. However, students' attitudes can vary significantly as multiple factors influence them. For instance, Ayebo, Bright, and Ballam (2019) reported that some students may genuinely be interested in statistics, appreciate statistics in research roles, and understand the world around them.

Meanwhile, some students exhibited disinterest, which might have difficulty perceiving the relevance of the statistics or may find it challenging (Hagen et al., 2013; de Oliveira Júnior et al., 2018). Some may experience anxiety and fear because of the perception of intricate calculations and mathematical concepts (Vanhoof et al., 2011). Others may perceive statistics negatively as challenging because of its abstract nature, complex ideas, or unfamiliar terminologies (Hagen et al., 2013). This negative attitude can hinder active class participation and motivation in learning statistics (Hagen et al., 2013). Implementing efficient teaching methods and assessment scales in quantifying it can yield meaningful information about students' attitudes and difficulties in statistics (Ayebo et al., 2019; Chiesi & Primi, 2009). The scales can also enable educators to identify any misconceptions or areas where improvement is needed so that they can intervene specifically.

Various assessment scales have been specifically created to evaluate students' perceptions of statistics. Prominent instances consist of the Statistics Attitude Survey conducted by Roberts and Bilderback (1980) and the Attitudes Toward Statistics survey by Wise (1985), both of which have been widely used. Moreover, the Survey of Attitudes toward Statistics (SATS) has been utilized in various versions, including SATS-28 and its extended version, which has 36 items. The SATS-28 has been used in Italy (Chiesi & Primi, 2009), while the SATS-36 has been applied in Russia (Khavenson, Orel, and Tryakshina, 2012), the Netherlands (Vanhoof, Kuppens, Sotos, et al., 2011), Turkey (Sarikaya et al., 2018), and Serbia (Stanisavljevic et al., 2014). Adapted versions of SATS-36 have been utilized in various cultural and educational contexts to investigate attitudes towards statistics implemented in different cultural and academic settings to examine attitudes toward statistics.

Moreover, both the SATS (Chiesi & Primi, 2009; Kakupa & Xue, 2019) and the ATR Scale (Hagen et al., 2013; Schau et al., 1995) have recognized the cognitive, emotional, and behavioral components of attitudes, enabling a quantitative evaluation of students' attitudes in statistics and research fields. This awareness facilitates targeted interventions to enhance students' attitudes, promoting engagement and ultimately improving their performance in both subjects.

Nonetheless, although ATR and SATS are crucial for assessing attitudes in different contexts, including their original English versions, there has been little effort to

validate and tailor them to the Filipino cultural and linguistic environment. This research sought to translate and assess the psychometric characteristics of the Attitudes Toward Statistics Scale (SATS-F) and Attitudes Toward Research (ATR-F) among Filipino nursing students. The validation of Filipino versions of measurement tools in this study enables cross-cultural comparisons and improves the global applicability of research results. This study offers culturally appropriate, dependable, and validated tools that facilitate precise evaluations of Filipinos' perspectives on statistics and research, thereby enhancing the generalizability and importance of research within this area.

Materials and Methods

Study Design

This study employed a cross-sectional design using a survey approach, consisting of two phases. Initially, the original English versions of the ATR and SATS were translated into Filipino. Subsequently, the translated versions underwent psychometric evaluation, assessing content validity, construct validity, and internal consistency.

Method

The study methods were divided into translating and assessing the psychometric qualities of ATR and SATS. Participants were Filipino nursing students at a Philippine university studying Bachelor of Science in Nursing, enrolled in nursing research and statistics classes, and aged at least 18 years old. Participants with >10% missing data on any tool were excluded.

Convenience sampling was used to recruit 372 participants. The sample size was determined using a 1:10 sample-to-item ratio (Costello & Osborne, 2005), resulting in 345 participants for 34 items across the two instruments. This sample size is further supported by the guidelines of MacCallum et al. (1999), who noted that samples above 300 are generally adequate for exploratory factor analysis when communalities are moderate to high. Furthermore, for factor analysis, Comrey and Lee (1992) classify a sample size of 300 as "good" and 500 as "very good." Significant Bartlett's tests of sphericity ($p < 0.001$) and the high Kaiser-Meyer-Olkin (KMO) values (0.85 for ATR-F and 0.92 for SATS-F) found in this study further support the suitability of the sample size for PCA.

Data were collected through MS Teams from August to October 2022. Informed consent and detailed instructions were provided before survey initiation. Data security and privacy were maintained through encrypted data transmission and storage. Weekly reminders were sent via email to encourage participation. The survey took approximately 10-15 minutes to complete. Participants were free to withdraw at any time with no penalty.

Instruments

Demographic characteristics, including age and gender, were included in the study. Attitudes toward Research Scale (ATR-F). The ATR-F Scale, developed by Papanastasiou (2014), measures research attitudes across three domains: usefulness of research (items 1-4), anxiety about research (items 5-8), and positive research disposition (items 9-13). Responses were recorded on a 7-point Likert scale (1 = strongly disagree, 7 = strongly agree). Negatively worded items were reversed to ensure higher scores indicated positive attitudes. Cronbach's alpha coefficients for the subscales were: usefulness of research ($\alpha = 0.90$), anxiety about research ($\alpha = 0.86$), and positive research predisposition ($\alpha = 0.92$).

Survey of Attitudes toward Statistics Scale (SATS-F). The SATS-F Scale, initially developed by Schau et al. (1995), assesses attitudes toward statistics across six components: affect, cognitive competence, value, difficulty, interest, and effort. Responses were answered on a 7-point Likert scale (1= totally disagree, 7 = totally agree). Negatively scored items were reversed, with higher scores indicating more positive attitudes. Cronbach's alpha values for the SATS-F subscales ranged from 0.64 to 0.88.

Data Analysis

The data were analyzed using SPSS version 24.0. Means, standard deviations (SDs), frequency counts, and percentages were computed for demographic profiles and scale items.

Item-Content Validity Index (I-CVI) and Scale-Content Validity Index (S-CVI/Ave) were examined using the averaging method (Polit and Beck, 2006). Items with I-CVI < 0.78 or S-CVI/Ave <0.90 were reviewed. Item-to-total correlations (ITCs) and Cronbach's alpha were computed. Items with ITC < 0.30 were removed.

Although Exploratory Factor Analysis (EFA) with Varimax rotation is often used in psychometric studies, PCA without rotation was utilized in this study. PCA was chosen for its ability to reduce data dimensionality and identify the underlying structure of the scale, aligning with approaches taken in similar validation studies. The decision not to apply Varimax rotation was based on the goal of maximizing total variance explained and preserving interpretability of unrotated components. PCA was performed to extract components. Kaiser-Meyer-Olkin (KMO) test and Bartlett's test of sphericity were conducted to ensure sampling adequacy and model appropriateness. Components with eigenvalue ≥ 1.00 and factor loading ≥ 0.40 were extracted. To further establish construct validity, a Pearson product-moment correlation coefficient was calculated to investigate the relationship between attitudes toward research and statistics. We hypothesized a positive correlation ($H_1: \rho > 0$).

Cronbach's alpha measured the internal consistency of the ATR-F and SATS-F. Cronbach's alpha ≥ 0.70 indicated good internal consistency (Nunnally and Bernstein, 1994).

Tool Translation and Validation

A systematic translation and validation process was employed for the ATR-F and SATS-F from English to Filipino to ensure cultural and linguistic equivalence. The translation process for cross-cultural adaptation followed the established protocol outlined by Beaton et al. (2000). A panel of seven experts, composed of two nurse researchers, four nursing research professors, and one academic program specialist, performed the forward and backward translation before the data collection. The review criteria included translation accuracy, language clarity, and cultural relevance. No significant modifications were made to the original tools during the translation process.

Ethical Considerations

Permission was obtained from the original authors of the tools for translation into Filipino. An ethics approval was obtained from the National University College of Allied Health Ethics Committee (Code: 2022-001CAH), and informed consent was secured from all participants. The study adhered to the Declaration of Helsinki and the ethics committee guidelines. Informed consent forms detailing the study purpose, procedures, risks, benefits, and duration were signed by participants before survey administration. Voluntary participation was emphasized, and participants could withdraw without penalty. No personal identifiable information (PII) was collected. Data were stored on a password-protected computer, accessible only to the primary investigator. Confidentiality was maintained throughout data analysis and reporting.

Results

Demographic data

A total of 345 students completely participated, yielding a response rate of 92.74%. Demographic profiles showed that respondents' ages ranged from 18 to 29 years, with a mean of 20.94 ($SD = 1.18$). Females constituted the majority of the respondents ($n = 282$, 81.7%), while males ($n = 63$, 18.3%).

Descriptive Analysis

As shown in Table 1, the item means of the ATR-F ranged from 4.45 for item 6 $SD = 1.51$) to 6.10 for items 1 ($SD = 1.24$) and 2 ($SD = 1.25$). Item 6 had the lowest ITC value of 0.43, while item 3 had the highest ITC value of 0.63. Based on these results, all items were included in the PCA.

For the SATS-F, the item means ranged from 2.88 ($SD = 1.38$; item 30) to 5.55 ($SD = 1.71$; item 7). As shown in Table 2, items 4 (ITC = 0.29), 5 (ITC = 0.28), 21 (ITC = 0.20), 22 (ITC = 0.26), 30 (ITC = −0.10), 34 (ITC = −0.15), and 36 (ITC = −0.27) had ITC values below 0.30. Therefore, we decided to remove them from the scale and exclude them from the PCA. Twenty-nine items were entered into the PCA. The final scale items, shown in

Table 1. Results of the item analyses on the Attitudes toward Research (ATR) - Filipino Version (n = 345)

Item	Mean	SD	Corrected item-total correlation	Cronbach's alpha if item is deleted
1. Research is useful for my career. *(Mahalaga ang pananaliksik sa aking trabaho.)*	6.10	1.24	0.60	0.862
2. Research is connected to my field of study. *(May kaugnayan ang pananaliksik sa aking larangan ng pag-aaral.)*	6.10	1.25	0.58	0.863
3. The skills I have acquired in research will be helpful to me in the future. *(Makatutulong sa aking sa hinaharap ang mga kasanayang natutunan ko sa pananaliksik.)*	6.01	1.25	0.63	0.860
4. Research should be compulsory in my professional training. *(Dapat gawing sapilitan ang pananaliksik sa aking propesyonal na pagsasanay.)*	5.06	1.49	0.49	0.868
5. Research courses make me anxious. *(Nakababahala ang mga kurso sa pananaliksik.)*	4.68	1.51	0.58	0.863
6. Research courses scare me. *(Nakakatakot ang mga kurso sa pananaliksik.)*	4.45	1.51	0.43	0.872
7. Research courses are stressful. *(Nakakai-stress ang mga kurso sa pananaliksik.)*	4.96	1.63	0.57	0.864
8. Research courses make me nervous. *(Nakakanerbiyos ang mga kurso sa pananaliksik.)*	4.63	1.58	0.50	0.867
9. Research courses are difficult. *(Mahirap ang mga kurso sa pananaliksik.)*	4.80	1.57	0.57	0.863
10. I enjoy my research course(s). *(Nasisiyahan ako sa aking (mga) kurso sa pananaliksik.)*	4.81	1.30	0.56	0.864
11. I love research courses. *(Gusto ko ang mga kurso sa pananaliksik.)*	4.59	1.25	0.54	0.865
12. I find research courses interesting. *(Nawiwili ako sa (mga) kurso sa pananaliksik.)*	5.00	1.31	0.55	0.864
13. Research courses are pleasant. *(Nakalulugod ang mga kurso sa pananaliksik.)*	5.01	1.25	0.60	0.862

Table 2. Results of the item analyses on the Survey of Attitudes toward Statistics (SATS)-Filipino version; Final model (n = 345)

Item	Mean	SD	Corrected item-total correlation	Cronbach's alpha if item is deleted
1. I tried to complete all of my Statistics assignments. *(Sinubukan kong kumpetuhin ang lahat ng takdang- aralin sa Statistics)*	5.27	1.45	0.51	0.890
2. I worked hard in my statistics course. *(Nagsumikap ako sa aking kursong Statistics)*	5.19	1.45	0.58	0.889
3. I like statistics. *(Gusto ko ang Statistics)*	4.34	1.43	0.54	0.890
6. Statistics formulas are easy to understand. *(Madaling maintindihan ang mga Statistics formulas).*	4.16	1.37	0.40	0.893
7. Statistics is worthless. *(Walang kwenta ang Statistics)*	5.55	1.71	0.38	0.893
8. Statistics is a complicated subject. *(Kumplikado ang kursong Statistics)*	3.37	1.53	0.30	0.897
9. Statistics should be a required part of my professional training. *(Mahalagang bahagi ng aking propesyonal na pagsasanay ang Statistics)*	4.63	1.39	0.46	0.891
10. Statistical skills will make me more employable. *(Makakatulong ang kasanayan sa Statistics sa aking kakayahang makapaghanap ng trabaho)*	4.77	1.35	0.53	0.890
11. I have no idea of what's going on in this statistics course. *(Wala aking ideya sa nangyayari sa kursong Statistics)*	4.55	1.57	0.51	0.890
12. I am interested in being able to communicate statistical information to others. *(Interesado akong maibahagi sa iba ang mga impormasyon sa Statistics.)*	4.67	1.38	0.56	0.889
13. Statistics is not useful to the typical professional. *(Hindi kapaki-pakinabang ang Statistics sa pangkaraniwang propesyonal.)*	4.83	1.62	0.47	0.891
14. I tried to study hard for every statistics test. *(Sinubukan kong mag-aral ng mabuti para sa bawat pagsusuri sa Statistics.)*	4.92	1.39	0.50	0.891
15. I get frustrated going over statistics tests in class. *(Nadidismaya ako tuwing binabalikan sa klase ang mga pagsusuri sa Statistics.)*	3.83	1.55	0.35	0.894
16. Statistical thinking is not applicable in my life outside my job. *(Hindi nagagamit ang estadistikang pananaw sa aking buhay labas sa trabaho ko.)*	4.50	1.54	0.52	0.890
17. I use statistics in my everyday life. *(Ginagamit ko ang Statistics sa pang-araw-araw na buhay.*	4.55	1.41	0.44	0.892
18. I am under stress during statistics class.) *(Naii-stress ako tuwing klase sa Statistics.)*	3.73	1.52	0.36	0.894
19. I enjoy taking statistics courses. *Nawiwili akong kumuha ng mga kursong Statisics.*	4.21	1.35	0.50	0.891
20. I am interested in using statistics. *(Interesado ako sa paggamit ng Statistics.)*	4.46	1.32	0.65	0.888
23. I am interested in understanding statistical information. *(Interesado akong maintindihan ang mga impormasyon sa estadistika.)*	4.72	1.33	0.67	0.887
24. Learning statistics requires a great deal of discipline. *(Kailangan ng sapat na disiplina sa pag-aaral ng Statistics.)*	5.29	1.30	0.53	0.890
25. I will have no application for statistics in my profession. *(Hindi ko magagamit ang Statistics sa aking trabaho.)*	4.50	1.53	0.46	0.891
26. I make a lot of math errors in statistics. *(Marami akong maling kalkulasyon sa Statistics.)*	3.75	1.40	0.31	0.894
27. I tried to attend every statistics class session. *(Sinubukan kong dumalo sa bawat sesyon ng klase sa Statistics.)*	4.80	1.51	0.43	0.892
28. I am scared by statistics. *(Takot ako sa Statistics.)*	3.94	1.61	0.40	0.893
29. I am interested in learning statistics. *(Interesado akong matuto ng Statistics.)*	4.92	1.44	0.64	0.888
33. Statistics is irrelevant in my life. *(Walang kinalaman ang Statistics sa buhay ko.)*	4.68	1.64	0.42	0.892
35. I find it difficult to understand statistical concepts. *(Nahihirapang akong intindihin ang mga konsepto sa Statistics.)*	3.66	1.41	0.34	0.894

[Table 2](#), had ITC values ranging from 0.30 (item 8) to 0.67 (item 23).

Those with ITC scores less than 0.30 were excluded from the final SATS-F scale. For borderline items (0.30–0.35) like item 8 (ITC = 0.30) and item 15 (ITC = 0.35), though, we used theory relevance and conceptual fit with the SATS framework. Item 8, for instance, captured perceived difficulty, one of the initial theoretical elements of SATS, and was deemed contextually appropriate for Filipino nursing students. This decision aligns with the best psychometric practices, where theoretical significance can justify retaining items close to statistical cutoffs (Nunnally & Bernstein, 1994). Furthermore, removing these items did not result in a meaningful improvement (>10%) in Cronbach's alpha, supporting their retention.

Content Validity

A six-member expert panel, comprising three nursing research professors, two statisticians, and one nurse

Table 3. Principal Components Analysis on the Attitudes toward Research – Filipino Version (n = 345)

Item	Factor 1 Anxiety about research	Factor 2 Positive research Disposition	Factor 3 Usefulness of research
Item 8	0.87		
Item 6	0.83		
Item 5	0.82		
Item 7	0.81		
Item 9	0.80		
Item 11		0.91	
Item 10		0.87	
Item 12		0.82	
Item 13		0.81	
Item 2			0.92
Item 1			0.91
Item 3			0.89
Item 4			0.48
Eigenvalue	5.36	2.92	1.51
Variance explained (%)	41.20	22.50	11.60
Cumulative variance explained (%)	41.20	63.70	75.30

Note. KMO = 0.85; Barlett's test of sphericity ($p < .001$)

researcher, examined the content validity of ATR-F and SATS-F. We incorporated participant feedback and reworded items as attitudinal statements to improve the tool's validity. The I-CVI values for ATR-F and SATS-F ranged from 0.83 to 1.00, exceeding the threshold of 0.78 (Polit & Beck, 2006). The computed S-CVI/Ave values were 0.94 for ATR-F and 0.98 for SATS-F, indicating good content validity (Lynn, 1986). These results support the content validity of both tools, ensuring they accurately measure attitudes toward research and statistics.

Construct Validity

Table 3 shows ATR-F PCA results. KMO measures of sampling adequacy were 0.85, and Bartlett's test of sphericity was statistically significant (p < 0.001), reflecting appropriate data for PCA. The factor extraction followed Kaiser's criterion (eigenvalue ≥ 1.0), and a scree plot was also analyzed to reinforce the decision in selecting the number of components to retain. Three components with eigenvalues ≥ 1.00 were extracted, explaining 75.3% of the variance. Component 1 (research anxiety) comprised items 5-9, accounting for 41.2% of the variance. Components 2 (positive research disposition) and 3 (usefulness of research) consisted of items 10-13 (22.5% variance) and items 1-4 (11.6% variance), respectively.

Two PCAs were conducted to optimize the model. Initially, 29 items were analyzed, yielding a KMO value of 0.92 and a significant Bartlett's test (p < .001). However, dimension four consisted of only two items (31 and 32), which cross-loaded with dimension one. These items were removed, and a second PCA was conducted with the remaining 27 items.

Table 4 shows the PCA results for the SATS-F. It revealed three components with eigenvalues ≥ 1.00,

Table 4. Principal Components Analysis on the Survey of Attitudes toward Statistics-Filipino Version (n = 345)

Items	Component 1 Aptitude	Component 2 Barriers	Component 3 Challenges
S20	0.87		
S23	0.85		
S12	0.81		
S29	0.78		
S10	0.77		
S19	0.77		
S3	0.75		
S14	0.75		
S2	0.73		
S9	0.70		
S6	0.69		
S1	0.69		
S24	0.68		
S17	0.67		
S27	0.63		
S7		0.83	
S13		0.82	
S33		0.74	
S25		0.73	
S16		0.72	
S11		0.71	
S18			0.79
S26			0.75
S35			0.74
S28			0.72
S8			0.70
S15			0.70
Eigenvalue	8.44	5.87	2.41
Variance explained (%)	31.30	21.80	8.90
Cumulative variance explained (%)	31.30	53.00	61.90

Note. KMO = 0.92; Barlett's test of sphericity ($p < 0.001$)

Table 5. Cronbach's alpha of the scales (n = 345)

Variable	Cronbach's alpha
Attitudes toward Research Scale	0.87
Anxiety about research	0.89
Positive research disposition	0.91
Usefulness of research	0.87
Attitudes Toward Statistics Scale	0.90
Aptitude	0.94
Barriers	0.90
Challenges	0.87

explaining 61.9% of the variance. The factor solution was also guided by Kaiser's criterion (eigenvalue ≥ 1.0), and the scree plot verified the three-component structure. Table 4 presents the PCA outcome of the SATS-F. It indicated three components with eigenvalues ≥ 1.00, accounting for 61.9% of the variance. Component 1 had 15 items (items 1, 2, 3, 6, 9, 10, 12, 14, 17, 19, 20, 23, 24, 27, and 29), with an eigenvalue of 8.44 and an explained variance of 31.3%. Six items were loaded in component 2 (7, 11, 13, 16, 25, and 33), accounting for 21.8% of the variance of the scale. Component 3 comprised six items (8, 15, 18, 26, 28, and 35), with an explained variance of 8.9%. Components 1, 2, and 3 were labeled *aptitude*, *barriers*, and *challenges*.

Reliability

We examined the reliability of the ATR-F and SATS-F using Cronbach's alpha. The ATR-F's overall alpha was 0.87, with subscale alphas ranging from 0.87 (anxiety about research) to 0.91 (usefulness of research). The SATS-F demonstrated high reliability, with an overall alpha of 0.90 and subscale alphas ranging from 0.87 (aptitude) to 0.94 (barriers). These values exceed the acceptable reliability threshold ($\alpha \geq 0.70$), indicating that both scales and their subscales are reliable for use among Filipino nursing students.

We also examined the relationship between nursing students' attitudes toward research (ATR-F) and statistics (SATS-F). The overall mean scores were 6.09 (SD = 0.88, range = 1.46–7.00) for ATR-F and 4.30 (SD = 0.74, range = 1.00–7.00) for SATS-F. Pearson's product correlation test revealed a strong positive correlation (r = 0.50, p < .001, q = 0.63), indicating a moderate to large effect size. This finding supports the construct validity of both scales and suggests that nursing students' attitudes toward research and statistics are closely related.

Discussions

This study examined the psychometric characteristics of the ATR-F and SATS-F among the Filipino population. Our results affirm the validity and reliability of these translated measures, establishing their trustworthiness and accuracy in the Filipino setting. The significance of stringent validation and reliability testing cannot be overemphasized, as cross-cultural differences and language discrepancies can noticeably influence respondents' interpretations and answers (Douglas and Craig, 2007). Researchers can confidently utilize these

scales in subsequent studies by adhering to precise methodological steps.

This study reported several significant findings. The ATR-F scale demonstrated cross-cultural consistency with psychometric properties similar to those of its Italian counterpart (Chiesi & Primi, 2009). Likewise, the SATS-F scale's good content validity, supported by Khavenson's et al. (2012) Russian version study, confirms its appropriateness for measuring attitudes toward statistics. These findings establish the consistency across cultures and languages, which enhances their generalizability and utility in diverse settings. Moreover, the results on internal construct validity were higher than the minimum correlation coefficient of 0.30; thus, the items were included in the PCA. Any item with a correlation coefficient higher than 0.30 was considered acceptable, and they indicated a relationship with the scale based on the criteria established by Nunnally and Bernstein (1994). This implies that the selected items had a significant relationship with the overall construct measured. Therefore, it is crucial to evaluate the different thresholds to ensure that sufficient information is preserved for accurate analysis.

While PCA does not directly assess construct validity, it can support validity by identifying patterns of correlations among items. The KMO measure and Bartlett's sphericity test supported the sample size adequacy. Specifically, all ATR-F ITCs were found to be above the predefined cut-off value. Removing any of the items did not result in an increase greater than 10% in the Cronbach's alpha coefficient for the entire scale. Therefore, we decided to retain all 13 items in the ATR-F and include them in the PCA.

Furthermore, PCA provided evidence of the existence of three distinct components within the ATR-F measure: (1) research anxiety, (2) positive research disposition, and (3) usefulness of research. These components closely resemble those found in the original version of the scale. Furthermore, PCA accounted for 75.5% of the explained variance in attitudes toward research, indicating a reasonable construct validity, which signifies that the scale captured a significant portion of the underlying factors influencing attitudes toward research, as Tabachnick and Fidell (2007) suggested. The three components identified in the analysis aligned well with the theoretical expectations and the original version of the scale.

For the PCA of SATS-F, the subsequent analysis shows that all remaining items were loaded appropriately after

removing items 31 and 32. Moreover, the scale's internal consistency increased when these items were deleted. It is essential to mention that the two items removed from the scale were positively worded. According to Nunnally and Bernstein ([1994](#)), it is customary to incorporate positive and negative worded items when creating self-report measures. One reason for removing the two positively worded items from the analytical process is to address the issue of acquiescence bias. Acquiescence relates to the participant's desire to concur with items regardless of their perception or experience (Rammstedt et al., [2017](#)). This bias can be brought about by such factors as having to pay more attention to the item than they originally intended. When participants show acquiescence bias, their dispositions towards agreeing with items can result in inflated scores on the scale. This inflation can compromise the validity and reliability of results obtained from its scale.

By removing the two positively worded items that did not fit the model, the authors aimed to improve the overall fit of the scale and ensure that the remaining items accurately reflected the SATS-F construct. This step helped enhance the validity and reliability of the results by eliminating potential sources of bias and ensuring that the scale items effectively measured the intended trait or characteristic. Similarly, the original scale consisted of six components: affect, cognitive competence, value, difficulty, interest, and effort. However, after the PCA, the scale was reduced to three components. It was categorized into Component 1, aptitude, consisted of 15 items (items 1, 2, 3, 6, 9, 10, 12, 14, 17, 19, 20, 23, 24, 27, and 29); Component 2, barriers, comprised six items (items 7, 11, 13, 16, 25, and 33); and component 3, challenges, included six items (items 8, 15, 18, 26, 28, and 35). The identification of these distinct components through the analysis indicates that the items in the SATS-F scale can be categorized into three meaningful clusters or factors. Each component represents a different aspect or dimension of the construct being measured by the scale. By reducing the scale to these three components, researchers and practitioners can focus on the key factors contributing to the measured construct. The components provide meaningful labels that help understand and interpret the scale's results more effectively. However, caution is needed in interpreting these findings at the cumulative explained variance of 61.9%, which indicates that the three identified components do not account for a significant portion of the variability in the SATS-F scale. This suggests that additional factors or dimensions may affect the construct but were not captured in the analysis.

Consequently, the three components identified may need to capture the measured construct's complexity and richness fully. Another is that the interpretation of the components and their labels (aptitude, barriers, and challenges) was based solely on the statistical analysis and the pattern of item loadings. While these labels

provide a convenient way to refer to the components, they should be interpreted cautiously and in conjunction with theoretical knowledge and qualitative insights. Replication studies with diverse samples would be beneficial in establishing the robustness and generalizability of the identified components.

The ATR-F scales showed strong internal consistency (α = 0.87), consistent with the Colombian version (De Becerra *et al.*, [2020](#)) and SATS-F (α = 0.90), respectively, indicating reliable measurements. However, variations across studies and cultural settings highlight the importance of considering linguistic and cultural factors Khavenson, Orel and Tryakshina ([2012](#)); Kiekkas et al. ([2015](#)). Interpretations should be cautious and informed by theoretical knowledge and qualitative insights. Replication studies with diverse samples are necessary to establish robustness and generalizability. Future research should investigate underlying causes of variations, validate scales across populations, and adapt to cultural and linguistic contexts to enhance reliability. This ensures accurate and meaningful assessments across different settings and populations.

The hypothesis testing also supports the tool's construct validity. The findings revealed a positive correlation (r = 0.50, p < 0.001) between nursing students' attitudes toward research and statistics. This association suggests that students with favorable attitudes toward research are more likely to have positive attitudes toward statistics (Oducado, [2021](#)). This finding aligns with Al Furaikh, Al Omairi, and Ganapathy's ([2017](#)) study, which highlighted the importance of promoting positive attitudes toward research and statistics among nursing students. Students with positive attitudes toward research and statistics are more likely to apply research findings in clinical decision-making (Kaufmann *et al.*, [2022](#)). Understanding the positive association between attitudes toward research and statistics can cultivate a nursing workforce that values evidence-based practice.

Overall, the SATS-F and ATR-F scales have demonstrated strong content validity, construct validity, and internal consistency across various populations and countries (Norris & Epstein, [2011](#); Nolan et al., [2012](#)). Researchers and practitioners can apply these scales in diverse settings (e.g., educational, clinical, community) to inform decision-making. Furthermore, they can identify students with unfavorable attitudes using the SATS-F and ATR-F, design targeted interventions to promote positive attitudes, and enhance statistical and research literacy among Filipino students.

The use of psychometrically validated instruments in nursing education transcends simple measurements such as tools for improving curriculum development, instruction, and individualized student support. The Survey of Attitudes Toward Statistics (SATS), for instance, assists in determining essential attitudes like

affect, cognitive competence, value, and perceived difficulty that are important for instructional adaptation to students' needs (Schau et al., 1995). These technologies enable the identification of where nursing students are having difficulty with statistical and research skills by faculty, thus allowing more tailored and effective support interventions.

Validated scales further enable the establishment of learner-focused curricula that are consistent with students' attitudes and confidence levels, which eventually enhance learning outcomes (Woltenberg, 2021). For example, students who receive initial foundational training in statistics are more likely to have positive attitudes, with high regard for initial and systematic exposure to statistical ideas (García-Martínez et al., 2015). Developing statistical literacy at the undergraduate level equips prospective nurses to critically examine and use research in clinical practice (Schreiber & Turk, 2022). Virtual and digital modules of learning have also been demonstrated to increase students' confidence in conducting statistical analysis and, accordingly, their applicability in professional development (Bindler & Saul, 2023). Statistics anxiety reduction strategies with targeted aims can considerably enhance students' attitudes along with their preparedness to conduct research (Ayaz-Alkaya & Terzi, 2024; Bindler & Saul, 2023). Diagnostic tests, such as cognitive tests, generate in-depth information on students' levels of skill and learning. This allows educators to create customized instruction strategies and learning plans that bridge the gaps in knowledge and facilitate statistical thinking (Maas et al., 2022). Psychometric tests are also helpful in tracking students over time, providing data against which to measure the impact of instructional innovations. Instructional design is also an essential part of developing students' attitudes toward research. For instance, theoretical research methods training has been known to yield more positive attitudes than courses that are applied only (Vrikki & Papanastasiou, 2024). Evidence-based instructional practices also improve student teachers' attitudes towards research and enhance motivation levels to engage in research activities (Ilhan, 2021). Therefore, empirically validated scales not only assess student attitudes and ability but also function as diagnostic and curriculum planning tools aiding the development of statistical literacy, research skills, and evidence-based practice.

This study acknowledges several limitations. First, translating scales from one language to another poses challenges in maintaining linguistic and cultural equivalence despite rigorous forward and back-translation procedures. Second, the pilot testing's limited scope at a single university may not accurately represent the broader Filipino nursing population, advising caution when generalizing findings. Third, convenience sampling may introduce biases, as participants were selected based on ease of access rather than random selection. Fourth, construct validity was primarily supported by hypothesis testing; however, additional methods like confirmatory and exploratory factor analyses are recommended to enhance instrument validation. Fifth, the scale's reliability was established through internal consistency, and supplementary measures like test-retest and inter-rater reliability are suggested.

Future research should investigate additional factors influencing the identified construct using diverse validity methods; replication studies are necessary among nursing students in various universities, and alternative statistical analyses should be employed to enhance instrument validation. Further research should examine the temporal reliability of the SATS-F and ATR-F using test-retest reliability and intraclass correlation coefficients (ICCs), further bolstering the evidence of time-based reliability.

Conclusion

Our study was the first attempt to translate and validate the ATR and SATS into Filipino. The findings demonstrated strong content validity, construct validity, and internal consistency, supporting the trustworthiness of the scales and providing confidence in their ability to consistently measure the research and statistical attitude. However, more rigorous validation and reliability assessments in different settings are suggested to enhance validity and establish generalizability.

Availability of data and materials

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Authors' contributions

Joseph U. Almazan: Conceptualization, Methodology, Data Curation, Writing – Original Draft Preparation, Visualization, Investigation, Writing – Reviewing & Editing.

Fritz Gerald V. Jabonete: Conceptualization, Methodology, Data Curation, Writing – Original Draft Preparation, Visualization, Investigation, Writing – Reviewing & Editing.

Cris S. Adolfo: Writing – Reviewing & Editing.

Abdulrhman S. B. Albougami: Writing – Reviewing & Editing.

Jose Arnold Tariga: Writing – Reviewing & Editing.

Jonas Preposi Cruz: Conceptualization, Methodology, Data Curation, Writing – Original Draft Preparation, Visualization, Investigation, Software Validation, Writing – Reviewing & Editing.

Declaration of Interest

The authors declare no conflict of interest in this research.

References

Ajzen, I. and Fishbein, M. (2000) Attitudes and the Attitude-Behavior Relation: Reasoned and Automatic Processes', *European Review of Social Psychology*, 11(1). Available at: https://doi.org/10.1080/14792779943000116.

Al Furaikh, S., Al Omairi, B. and Ganapathy, T. (2017) 'A cross-sectional survey on nursing students' attitude towards research', *Journal of Health Specialties*, 5(4). Available at: https://doi.org/10.4103/jhs.jhs_36_17.

Ayaz-Alkaya, S., & Terzi, H. (2024). Effectiveness of scientific research education programme on the attitudes of nursing students towards research methods course: a pre and post-implementation study. *Contemporary Nurse*, 1–9. https://doi.org/10.1080/10376178.2024.2310265

Ayebo, A., Bright, J. and Ballam, C. (2019) 'Examining the Factor Structure of the Survey of Attitudes Towards Statistics among Undergraduate Health Science Students', *International Electronic Journal of Mathematics Education*, 15(1). Available at: https://doi.org/10.29333/iejme/5942.

Beaton, D.E. *et al.* (2000) 'Guidelines for the process of cross-cultural adaptation of self-report measures', *Spine*. Available at: https://doi.org/10.1097/00007632-200012150-00014.

Bindler, R. J., & Saul, T. (2023). Stats lab: Piloting live digital statistics learning modules for nurses at a multicenter health institution in the Western United States. *Teaching and Learning in Nursing*. https://doi.org/10.1016/j.teln.2023.07.011.

De Becerra, G.M.A. *et al.* (2020) 'Attitudes towards Research Scale (ATRS): Evaluation of its psychometric properties in a Colombian Sample', *Revista CES Psicologia*, 13(1). Available at: https://doi.org/10.21615/CESP.13.1.6.

Chiesi, F. and Primi, C. (2009) 'Assessing statistics attitudes among college students: Psychometric properties of the Italian version of the Survey of Attitudes toward Statistics (SATS)', *Learning and Individual Differences*, 19(2), pp. 309–313. Available at: https://doi.org/10.1016/j.lindif.2008.10.008.

Comrey, A.L., & Lee, H.B. (1992). *A first course in factor analysis* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum Associates.

Connor, L. *et al.* (2023) 'Evidence-based practice improves patient outcomes and healthcare system return on investment: Findings from a scoping review', *Worldviews on Evidence-Based Nursing*. Available at: https://doi.org/10.1111/wvn.12621.

Costello, A.B. and Osborne, J.W. (2005) 'Best practices in exploratory factor analysis: Four recommendations for getting the most from your analysis', *Practical Assessment, Research and Evaluation*, 10(7).

Douglas, S.P. and Craig, C.S. (2007) 'Collaborative and iterative translation: An alternative approach to back translation', *Journal of International Marketing*. Available at: https://doi.org/10.1509/jimk.15.1.030.

Eagly, A.H. and Chaiken, S. (2007) 'The advantages of an inclusive definition of attitude', *Social Cognition*, 25(5). Available at: https://doi.org/10.1521/soco.2007.25.5.582.

García-Martínez, J. A., Fallas-Vargas, M. A., & Romero-Hernández, A. (2015). Las actitudes hacia la estadística del estudiantado de orientación. *Revista Electronic@ Educare*, 19(1), 25–41. https://doi.org/10.15359/REE.19-1.2

Hagen, B. *et al.* (2013) 'Evaluation of undergraduate nursing students' attitudes towards statistics courses, before and after a course in applied statistics', *Nurse Education Today*, 33(9), pp. 949–955. Available at: https://doi.org/10.1016/j.nedt.2012.11.005.

Ilhan, N. (2021). The Effect of Research Evidence-Based Teaching Practices in Science Classrooms on Student Teachers' Attitudes towards Educational Research. *Journal of Science Learning*. 4(4), 316–326. https://doi.org/10.17509/JSL.V4I4.32025

Kakupa, P. and Xue, H. (2019) 'Students' Attitudes towards Research: A Study of Graduate Education Students at a Chinese Normal University', *Educational Process: International Journal*, 8(2), pp. 97–110. Available at: https://doi.org/10.22521/edupij.2019.82.1.

Kaufmann, L. *et al.* (2022) 'Self-efficacy matters: Influence of students' perceived self-efficacy on statistics anxiety', *Annals of the New York Academy of Sciences*, 1514(1), pp. 187–197. Available at: https://doi.org/10.1111/nyas.14797.

Khan, K.A. *et al.* (2021) 'Construction and Piloting of Attitude Towards Research Participation Scale for University Students', *Psychology Research and Behavior Management*, 14, pp. 2071–2079. Available at: https://doi.org/10.2147/PRBM.S333450.

Khavenson, T., Orel, E. and Tryakshina, M. (2012) 'Adaptation of Survey of Attitudes Towards Statistics (SATS 36) for Russian Sample', *Procedia - Social and Behavioral Sciences*, 46, pp. 2126–2129. Available at: https://doi.org/10.1016/j.sbspro.2012.05.440.

Kiekkas, P. *et al.* (2015) 'Nursing students' attitudes toward statistics: Effect of a biostatistics course and association with examination performance', *Nurse Education Today*, 35(12), pp. 1283–1288. Available at: https://doi.org/10.1016/j.nedt.2015.07.005.

Lynn, M. (1986) 'Determination and Quantification of Content Validity', *Nursing Research* [Preprint].

Maas, L., Brinkhuis, M. J. S., Kester, L., & Wijngaards-de Meij, L. (2022). Cognitive Diagnostic Assessment in University Statistics Education: Valid and Reliable Skill Measurement for Actionable Feedback Using Learning Dashboards. *Applied Sciences*, 12(10), 4809. https://doi.org/10.3390/app12104809

MacCallum, R.C., Widaman, K.F., Zhang, S., & Hong, S. (1999). *Sample size in factor analysis*. Psychological Methods, 4(1), 84–99.

Nolan, M.M., Beran, T. and Hecker, K.G. (2012) 'Surveys assessing students' attitudes toward statistics: A systematic review of validity and reliability', *Statistics Education Research Journal*, 11(2). Available at: https://doi.org/10.52041/serj.v11i2.333.

Norris, P. and Epstein, S. (2011) 'An experiential thinking style: Its facets and relations with objective and subjective criterion measures', *Journal of Personality*, 79(5), pp. 1043–1080. Available at: https://doi.org/10.1111/j.1467-6494.2011.00718.x.

Nunnally, J.C. and Bernstein, I.H. (1994) *Psychometric theory*. 3rd edn, *Philosophical Magazine*. 3rd edn. New York: McGraw Hill.

Oducado, R.M.F. (2021) 'Factors Affecting Nursing Students' Attitude Towards Research: A Survey in a Philippine Higher Education Institution', *Jurnal Ilmiah Ilmu Keperawatan Indonesia*, 11(01). Available at: https://doi.org/10.33221/jiiki.v11i01.956.

de Oliveira Júnior, A.P. *et al.* (2018) 'Student's Attitudes Towards Probability and Statistics and Academic Achievement on Higher Education', *Acta Didactica Napocensia*, 11(2), pp. 43–56. Available at: https://doi.org/10.24193/adn.11.2.4.

Padagas, R.C. and Hajan, B.H. (2020) 'Academic reading and writing needs of undergraduate nursing students in research', *International Journal of Learning, Teaching and Educational Research*, 19(5), pp. 318–335. Available at: https://doi.org/10.26803/ijlter.19.5.20.

Papanastasiou, E.C. (2014) *A First Look at its Psychometric Properties, Attitudes Toward Research Scale (R-ATR.*

Polit, D.F. and Beck, C.T. (2006) 'The content validity index: Are you sure you know what's being reported? Critique and recommendations', *Research in Nursing and Health*, 29(5), pp. 489–497. Available at: https://doi.org/10.1002/nur.20147.

Rammstedt, B., Danner, D. and Bosnjak, M. (2017) 'Acquiescence response styles: A multilevel model explaining individual-level and country-level differences', *Personality and Individual Differences*, 107. Available at: https://doi.org/10.1016/j.paid.2016.11.038.

Rind, Z. (2020) 'Attitude of students towards research: A review', *International Journal of Multidisciplinary Research and Development*, 7(5), pp. 101–102. Available at: www.allsubjectjournal.com.

Roberts, D.M. and Bilderback, E.W. (1980) 'Reliability and validity of a statistics attitude survey', *Educational and Psychological Measurement*, 40(1), pp. 235–238. Available at: https://doi.org/10.1177/001316448004000138.

Sarikaya, E.E. *et al.* (2018) 'Turkish version of the survey of attitudes toward statistics: Factorial structure invariance by gender', *International Journal of Higher Education*, 7(2). Available at: https://doi.org/10.5430/ijhe.v7n2p121.

Schau, C., Stevens, J. J., Dauphinee, T. L., & Del Vecchio, A. (1995). The development and validation of the Survey of Attitudes toward Statistics. *Educational and Psychological Measurement*, 55(5), 868–875. https://doi.org/10.1177/0013164495055005022

Schreiber, J. B., & Turk, M. T. (2022). *Statistics and Data Analysis Literacy for Nurses*. https://doi.org/10.1891/9780826165824

Sin & Rosli (2020) 'Validity and Reliability of the Survey of Attitudes Toward Statistics (SATS) Instrument (Kesahan dan Kebolehpercayaan Instrumen Survey of Attitudes Toward Statistics (SATS)', *Jurnal Pendidikan Malaysia*, 45(01SI), pp. 17–24. Available at: https://doi.org/10.17576/jpen-2020-45.01si-03.

Stanisavljevic, D. *et al.* (2014) 'Assessing attitudes towards statistics among Medical students: Psychometric properties of the Serbian Version of the survey of attitudes towards statistics (SATS)', *PLoS ONE*. Public Library of Science. Available at: https://doi.org/10.1371/journal.pone.0112567.

Tabachnick, B.G. and Fidell, L.S. (2007) 'Using multivariate statistics (5th ed.)', *Using multivariate statistics* [Preprint], (April).

Tempelaar, D.T., Schim Van Der Loeff, S. and Gijselaers, W.H. (2007) 'A Structural Equation Model Analyzing the Relationship of Students' Attitudes Toward Statistics, Prior Reasoning Abilities and Course Performance', *Statistics Education Research Journal*, 6(2), pp. 78–102. Available at: http://www.stat.auckland.ac.nz/serj.

Tran-Chi, V.-L. (2019) 'Exploring Vietnamese Psychology Undergraduates' Attitudes towards Research', *International Journal of Educational Sciences*, 25(1–3), pp. 51–57. Available at: https://doi.org/10.31901/24566322.2019/25.1-3.1082.

Vanhoof, S., Kuppens, S., Elisa, A., *et al.* (2011) *Measuring Statistics Attitudes: A Structure of the Survey of Attitudes Towards Statistics (SATS-36)*. Aukland. Available at: http://www.evaluationandstatistics.com/index.html.

Vanhoof, S., Kuppens, S., Sotos, A.E.C., *et al.* (2011) 'Measuring statistics attitudes: Structure of the survey of attitudes toward statistics (SATS-36)', *Statistics Education Research Journal*, 10(1). Available at: https://doi.org/10.52041/serj.v10i1.354.

Vrikki, M., & Papanastasiou, E. C. (2024). Research attitudes among pre-service teachers: unexpected outcomes emerging from a natural experiment. *Journal of Applied Research in Higher Education*. https://doi.org/10.1108/jarhe-07-2023-0282

Wise, S.L. (1985) 'The Development and Validation of a Scale Measuring Attitudes toward Statistics', *Educational and Psychological Measurement*, 45(2), pp. 401–405. Available at: https://doi.org/10.1177/001316448504500226.

Woltenberg, L. N. (2021). Cultivating Statistical Literacy Among Health Professions Students: a Curricular Model. *Medical Science Educator*, 31(2), 417–422. https://doi.org/10.1007/S40670-021-01256-4

Wongvorachan, T., Srisuttiyakorn, S., & Sriklaub, K. (2024). Optimizing Learning: Predicting Research Competency via Statistical Proficiency. *Trends in Higher Education*, 3(3), 540–559. https://doi.org/10.3390/higheredu3030032