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Study Skills of Undergraduate Public Health Students During Post COVID-19 New Normal: Validity and Reliability of SSAQ-CCHU Instrument

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Abstract

In the evolving post-COVID-19 educational landscape, this study developed and validated the SSAQ-CCHU, a study skills assessment scale for public health students. Using a cross-sectional design, 302 students participated in exploratory factor analysis (EFA) and 135 in confirmatory factor analysis (CFA). The final scale, comprising three constructs—motivation and attitude, test strategy and comprehension, and processing information—demonstrated strong model fit ($\chi^2/df = 2.45$, CFI = 0.92, RMSEA = 0.05) and high internal consistency (Cronbach's $\alpha = 0.88$). Significant differences were found in "Processing information" skills across majors ($p = 0.016$) and in "Motivation and attitude" between genders ($p = 0.01$). These findings affirm the scale's validity and reliability, providing a practical tool for educators and policymakers to assess and enhance student study skills in diverse learning environments.

Keywords: *Study Skills, Validity, Post-COVID-19 New Normal, Confirmatory Factor Analysis, Recovery Strategies, Pandemic Recovery.*

Introduction

Higher education students encounter diverse challenges in their academic journeys, with the mastery of study skills emerging as a critical determinant of success. Researchers and educators widely acknowledge the pivotal role of study skills in fostering academic achievement (Aesa & Ampuni, 2021; Agasisti & Johnes, 2010; Alanazy, 2022; Alharbi, 2023). Rafoth and DeFabo (2005) conceptualize study skills as multifaceted processes involving planning, organizing, and synthesizing information to optimize learning. These skills encompass specific behaviors such as note-taking (Chang & Kim, 2017), reading comprehension, and written expression (Bidjerano, 2005), which collectively enhance academic performance and deepen subject-matter understanding. Beyond technical competencies, factors like motivation—the internal drive to engage, persist, and focus despite challenges—significantly shape learning approaches (Amiryousefi, 2019; Arnett, 2020; Clump, Bauer, & White, 2003). Time management further

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enables students to allocate resources efficiently, prioritize tasks, and achieve goals (Daniel, 2020), while test preparation strategies, memory techniques, concentration, and anxiety management determine students' ability to demonstrate their potential in assessments (Chang & Kim, 2017).

Building on this foundation, the study skills framework is organized into eight dimensions: Motivation, Time Management, Test Preparation/Test Anxiety, Organizing/Processing Information, Reading, Writing, Memory/Concentration, and Note-Taking. This structure provides a holistic lens for evaluating students' academic strategies. Existing assessment tools, such as the Study Skills Inventory (SSI) and self-assessment scales from institutions like the University of Lynchburg and South Utah University, focus on subsets of these dimensions—notably time management, reading, note-taking, and test preparation (Bawa'aneh, 2011; Donche, Coertjens, & Van Petegem, 2013; Hattie, Biggs, & Purdie, 1996). However, these tools often neglect critical psychological and cognitive components like motivation and information processing. In contrast, the Study Skills Assessment Questionnaire for College Students (SSAQ-CCHU) (Baticulon, Luceno, Alberto, & Raymundo, 2021) offers a more comprehensive evaluation by integrating all eight dimensions. Its inclusion of motivation and organizing/processing information addresses intrinsic drivers of learning and higher-order cognitive engagement, bridging gaps in traditional scales (Rafoth & DeFabo, 2005; Amiryousefi, 2019; Arnett, 2020; Clump, Bauer, & White, 2003).

The SSAQ-CCHU's robustness is evidenced by its cross-cultural validation in Iran, Zambia, and Saudi Arabia, demonstrating strong internal consistency ($\alpha = 0.70–0.89$) and reliability across diverse student populations, including health professions learners (Allamai & Aldosari, 2020; Alsulami & Alharbi, 2023; Azila, 2010). This adaptability underscores its utility in varied educational contexts, particularly in capturing shifts in study behaviors prompted by global disruptions like the COVID-19 pandemic.

The COVID-19 pandemic catalyzed unprecedented shifts in education, with emergency remote teaching (ERT) becoming ubiquitous. While research has extensively explored students' perceptions of online learning, assessments, and peer interactions during this period (Aristovnik, Keržič, Kermavnar, Fidanoski, & Liče, 2020; Baticulon, Luceno, Alberto, & Raymundo, 2021), scant attention has been paid to the evolving study skills required in the post-pandemic "new normal." As institutions transition back to in-person learning, students must navigate hybrid environments, blending digital fluency with traditional academic demands. The pandemic's uncertainties eroded many learners' motivation, focus, and perseverance (Chhabra, Kulshrestha, & Rawat, 2021), amplifying the need for adaptive study strategies. For instance, while online exams offered flexibility in timing and format, in-person assessments now require renewed proficiency in time-bound problem-solving, memorization, and anxiety management within structured settings (Aristovnik, Keržič, Kermavnar, Fidanoski, & Liče, 2020).

This transition highlights the urgency of reevaluating study skills frameworks to address contemporary challenges. Existing tools, designed for pre-pandemic or fully online contexts, may no longer capture the hybridized competencies students need. The SSAQ-CCHU's multidimensional structure positions it as a viable instrument for this purpose, yet its applicability in the post-COVID-19 era remains underexplored.

With this in mind, this study explored the SSAQ-CCHU tool and created a measurement model in order to answer the following research questions; RQ1: What latent factors of study skills are identified in the improved SSAQ-CCHU scale to fit the context of post COVID-19 new

normal? RQ2: How are the validity and reliability of the improved SSAQ-CCHU scales? RQ3: What are the main variations in the public health students' study skills across various groups? Consequently, this study aimed to develop and quantitatively validate a robust and contextually relevant study skill assessment model based on SSAQ-CCHU. Furthermore, demographic comparisons identified at-risk subgroups, enabling institutions to allocate resources equitably.

The post-COVID-19 educational landscape demands a recalibration of study skills frameworks to reflect hybrid learning environments and lingering psychosocial impacts. This study advances the SSAQ-CCHU as a comprehensive, culturally adaptable tool for this purpose, bridging theoretical and practical gaps in academic support. By elucidating skill disparities across student groups, it equips educators and policymakers to foster resilience and adaptability in evolving educational contexts.

Method

Study design and research instrument

This cross-sectional study employed the Study Skills Assessment Questionnaire of the Counseling Center of Houston University (SSAQ-CCHU) (Baticulon et al., 2021) as the primary data collection tool. The SSAQ-CCHU comprises 64 items across eight constructs **(Table 1),** each addressing a distinct dimension of study skills: Motivation, Time Management, Test Preparation/Test Anxiety, Organizing/Processing Information, Reading, Writing, Memory/Concentration, and Note-Taking. Aligned with the conceptual framework outlined in the literature (Allamai & Aldosari, 2020; Alsulami & Alharbi, 2023; Azila, 2010; Bawa'aneh, 2011; Donche, Coertjens, & Van Petegem, 2013; Hattie, Biggs, & Purdie, 1996), the SSAQ-CCHU offers a comprehensive evaluation of study skills, integrating both behavioral and cognitive components. Its robustness has been validated in diverse cultural contexts, including Iran, Saudi Arabia, and Zambia, demonstrating strong internal consistency (Cronbach's α: 0.82–0.93) (Broadbent, Osborne, & Brierley, 2018; Buzdar, Ali, & Tariq, 2019; Chang & Kim, 2017).

The SSAQ-CCHU's theoretical grounding and multidimensional structure make it particularly suited for assessing study skills in the post-COVID-19 educational landscape, where hybrid learning models demand adaptability in skill application.

Construct	**Description (Items)**
Time Management and Procrastination	Involving arriving to classes on time, setting aside enough time for studying, creating a "to-do" list with clear goals, having an organized daily schedule with fewer activities that interfere with it, making the most out of prime hours for studying in an alert state, and preparing for major course assignments in advance. (Items: time1-time8)
Concentration and Memory	Entailing studying in a quiet and distraction-free environment, maintaining focus on the task at hand, and having a deep understanding of the material to be remembered. (Items: cm1-cm8)
Study Aids and Note-Taking	Including taking notes to help understand lectures and discussions, as well as how to review, edit, and organize them. (Items: sa1-sa8)
Test Anxiety and Test Strategies	Covering how to best prepare for exams and minimize pre-exam anxiety. (Items: ts1-ts8)
Organizing and	Involving studying with a critical attitude, organizing facts, and

Processing Information	identifying key points in learning materials. (Items: pi1-pi8)
Motivations and Attitudes	Including participating in class activities such as asking and answering questions, discussing in class, and taking the initiative in group activities. (Items: ma1-ma8)
Reading and Selecting Main Ideas	Involving sharpening skills such as focusing on the key points, summarizing main ideas in one's own words, following a writer's structure, and skimming through a chapter before reading. (Items: sm1-sm8)
Writing Skills	Encompassing expressing thoughts, developing rough drafts from notes, narrowing down topics for essays, and setting aside enough time for gathering information, organizing materials, and writing assignments. (Items: w1-w8)

Table 1. Overview of Study Skill Constructs and Their Descriptions

Content Validity Assessment of the Thai Version of SSAQ-CCHU

The English version of the SSAQ-CCHU was translated into Thai through a rigorous forward-backward translation process by bilingual educators. The translated draft was reviewed by a panel of four academic experts to ensure linguistic accuracy and cultural relevance. Content validity was assessed by three independent reviewers with expertise in educational psychology and public health. Each item was rated on a 4-point scale:

Rating of 1 (Not Relevant or Unclear): Fails to measure study skills or is ambiguous Rating of 2 (Needs Major Revision): Relevant but requires substantial rephrasing Rating of 3 (Needs Minor Revision): Generally clear but could benefit from refinement Rating of 4 (Relevant and Clear): Directly and unambiguously measures the target construct.

The Item-Level Content Validity Index (I-CVI) was calculated as the proportion of experts rating an item ≥ 3. The Scale-Level Content Validity Index (S-CVI/Ave) was derived by averaging all I-CVIs. A threshold of S-CVI/Ave ≥ 0.90 was adopted to confirm validity (Clump, Bauer, & White, 2003; Credé & Kuncel, 2008). The Thai SSAQ-CCHU achieved an S-CVI/Ave of 0.93, indicating excellent content validity.

Feedback from experts led to minor revisions in phrasing for clarity (e.g., simplifying technical terms for broader accessibility).

Procedure

The study followed a structured three-phase protocol:

1. Translation and Validation: The SSAQ-CCHU was translated, reviewed, and validated for content.

2. Exploratory Factor Analysis (EFA): Administered to 302 students to identify latent factors and refine the scale.

3. Confirmatory Factor Analysis (CFA): Tested the refined model on 135 students to confirm construct validity.

Data collection occurred between June and November 2022. Students from three undergraduate public health programs—Environmental Health (EH), Occupational Health and Safety (OHS),

and Community Public Health (CPH)—were included. All participants had experienced both pre-pandemic in-person learning and post-pandemic hybrid/online modalities.

Sample size and data collection

From an initial pool of 487 students, 437 met inclusion criteria (90% retention after removing incomplete responses). Stratified random sampling ensured proportional representation across programs (EH: 12.3%, OHS: 21%, CPH: 66.7%) and academic years. Participation was voluntary, with informed consent obtained. Ethical approval ensured anonymity and compliance with institutional guidelines.

Inclusion Criteria:

- Enrollment in EH, OHS, or CPH programs.
- Exposure to both pre- and post-COVID-19 learning environments.
- Willingness to provide informed consent.

Data Analysis

Exploratory Factor Analysis (EFA)

EFA was conducted using IBM SPSS 20.0 software version 20.0 (George & Mallery, 2019) to identify latent constructs and refine the scale. Cases with incomplete responses were excluded. The normality of the data was examined by inspection of skewness and kurtosis that varied from -2 to +2, to prove normal univariate distribution (Daniel, 2020). The principle axis factoring was chosen for its robustness to non-normal data and ability to detect weak factors (Diseth et al., 2010; Donche, Coertjens, & Van Petegem, 2013). Factors with eigenvalues > 1.0 were retained. Varimax rotation was used to simplify factor structure by maximizing variance across factors. Factor loading value ≥ 0.40 was for inclusion (Duncan & McKeachie, 2005). Items loading ≥ 0.40 on multiple factors were discarded (Eachempati et al., 2021). Items should have communalities ≥ 0.25 to ensure adequate shared variance (El Ansari, Oskrochi, & Phillips, 2011). Minimum items required at least 3 items retained per factor (El-Zraigat, 2011). For assumptions, Kaiser-Meyer-Olkin (KMO) with value ≥ 0.50 indicated sampling adequacy (Farooq et al., 2011). Bartlett's Test of Sphericity (BTOS) with p-value < 0.05 confirmed inter-item correlations (Felder & Brent, 2016). For the internal consistency reliability, Cronbach alpha value equal to 0.70 or higher is considered acceptable (Diseth et al., 2010).

Confirmatory Factor Analysis (CFA)

CFA was performed using IBM AMOS 20.0 to validate the EFA-derived structure. Model specification defined the theoretical relationship between latent variables corresponded to EFA-identified factors and observed variables represented retained questionnaire items. Maximum Likelihood (ML) was used for parameter estimation.

Goodness of fit indices: The absolute fit indices included $\chi^2/df \leq 3$ (Fereidouni & Abolfazli Khonamri, 2015), RMSEA ≤ 0.07 (acceptable), ≤ 0.05 (excellent) (Diseth et al., 2010; Fryer & Elliot, 2007; García & Doménech, 2010). The p-value tests the null hypothesis that RMSEA is ≤ .05, and thus p- value is greater than .05 to accept the null hypothesis, and GFI ≥ 0.90 (Gaspar et al., 2016; George & Mallery, 2019). Relative fit indices consisted of the Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), and Incremental Fit index (IFI) with values ≥ 0.95 (El-Zraigat, 2011).

Parsimony Fit: Standardized Root Mean-squared Residuals (SRMR) ≤ 0.08 indicated relatively good fit between the hypothesized model and the observed data (Hair et al., 2010).

Model modifications: It required additional re-specification by (i) covariances added with modification index (MI) > 10 and (ii) removing a parameter with a non-significant path from the model, (iii) removing observed variables if the standardized residuals were greater than 2, (iv) excluding items with factor loading lower than 0.6 in order to achieve the unidimensionality.

Assessment of Reliability and Validity

Assessment of the construct reliability: The Cronbach's alpha value and composite reliability (CR) should be greater than 0.70 to ensure robustness (Diseth et al., 2010; Hair et al., 2010). Assessment of convergent validity: The average variance extracted (AVE) ≥ 0.5 suggested that more than half of the variance in the indicators is attributed to the construct they are intended to measure (Hattie, Biggs, & Purdie, 1996). The CR value exceeds 0.70, indicating a high level of internal consistency among the indicators. Assessment of discriminant validity: It assesses the degree of differences between overlapping constructs (Hsin & Cigas, 2013), including Pearson correlations less than 0.8 between constructs, Fornell& Larcker criterion and the Heterotrait-monotrait (HTMT) ratio of correlations (Hung & Nguyen, 2022). For the Fornell & Larcker criterion, the square root of AVE should have a greater value than the correlations with other latent constructs (Hsin & Cigas, 2013). The HTMT ratio below the threshold of 0.85 indicate that the constructs are distinguishable (Hsin & Cigas, 2013).

Analysis of the differences of scores on constructs of CFA scales across different student groups

Non-parametric tests were used due to non-normal data distributions. Kruskal-Wallis Test compared median scores across academic years, majors, and age groups. Mann-Whitney U Test: compared gender differences of median scores with the significance threshold: $p < 0.05$. All tests were performed using IBM® SPSS AMOS 20 software.

Results

Sample Characteristics

Table 2 presents the overall sample characteristics. For the total sample, the student's mean age was 19.68 years (SD = 1.34), and 12.36% of the students were male. The majority of students were studying in the first year (43.48%), and the major of study was Community Public Health (66.37%).

	Sample for EFA	Sample for CFA	Total sample
N	302	135	437
Age			
Mean	19.74	19.54	19.68
SD	1.32	1.38	1.34
Gender			
Male	34 (11.3%)	20 (14.8%)	54 (12.36%)
Female	268 (88.7%)	115 (85.2%)	383 (87.64%)
Year of study			

1st year	124 (41.1%)	66 (48.9%)	190 (43.48%)
2nd year	62 (20.5%)	22 (16.3%)	84 (19.22%)
3rd year	64 (21.2%)	18 (13.3%)	82 (18.76%)
4th year	52 (17.2%)	29 (21.5%)	81 (18.53%)
Major of study			
1/ Community Public Health (CPH)	198 (65.6%)	92 (68.1%)	290 (66.37%)
2/ Occupational Health (OH)	64 (21.2%)	28 (20.7%)	92 (21.05%)
3/ Environmental Health (EH)	40 (13.2%)	15 (11.1%)	55 (12.58%)

Table 2. Description of Demographic Characteristics in Three Samples

Initial model from EFA

The SSAQ-CCHU, including 64 items, was distributed to the 302 public health students for performing an exploratory factor analysis of study skills scales. The KMO value was 0.931, and Bartlett's test of sphericity was significant with *p* value less than 0.0001. These results together demonstrate that the dataset is suitable for conducting factor analysis and exploring the underlying structure of the data. All the item's extracted communalities (0.25-0.65) were indicated as acceptable. EFA detected a 8-factor structure solution with 37 items that explained 53.36 % of the total variance (Hair et al., 2010). All factor loadings were significant with values greater than 0.40, indicating an adequate proportion of common variance among the items in each scale. The eight factors extracted from the data were nearly similar to the constructs of the original SSAQ-CCHU but rather different in the number of items on each factor and contents. EFA results revealed the reduction from 64 items to 37 items. Eight constructs namely motivation, attitude and active learning (F1), anxiety strategy and comprehension (F2), note-taking (F3), reading and selecting the main idea (F4), organizing information (F5), test strategy (F6), concentration and memory (F7), and time management (F8) were inter-related by symbols of two-headed arrows **(Fig.1).** Besides, 37 indicators (observed variables) were enclosed in squares. The numbers on the arrows depicted the correlation coefficient between constructs and the standardized regression weights of the observed variables. The symbols e1 - e37 were considered errors in the measurement model **(Fig.1).**

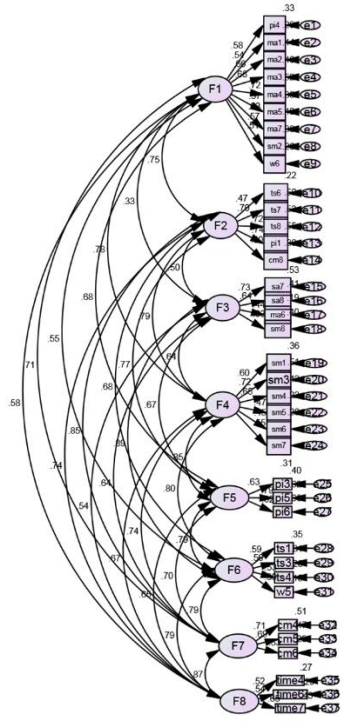

Fig.1 Initial Model of Study Skills Extracted From SSAQ-CCHU

Assessment of construct reliability

Table 3 showed the overall Cronbach's alpha value of 0.944 (Diseth et al., 2010). The Cronbach's alpha value and composite reliability (CR) of each construct exceed 0.7, indicating acceptable reliability of the data and good internal consistency. These high values demonstrate that the observed items within each construct are consistently measuring the same underlying construct.

Factor	**Item**	**Factor loading***	**CR (> 0.7)**	**AVE (> 0.5)**	**Cronbach's alpha**
Motivation & attitude and active learning subscale (F1)			0.90	0.5	0.890
Motivation and attitude	Ma1 Ma2 Ma3 Ma4 Ma5 Ma7	0.694 0.580 0.653 0.778 0.709 0.566			
Outlining and researching	Sm2 W6 Pi4	0.482 0.434 0.423			

Test strategy and comprehension subscale (F2)			0.87	0.58	0.838
Test strategy for exams	Ts6 Ts7 Ts8	0.531 0.639 0.664			
Information retention and comprehension	Pi1 Cm8	0.619 0.417			
Note-taking subscale (F3)			0.85	0.6	0.722
	Sa7 Sa8 Ma6 Sm8	0.717 0.455 0.547 0.504			
Reading & selecting main idea subscale (F4)			0.84	0.48	0.821
	Sm1 Sm3 Sm4 Sm5 Sm6 Sm7	0.422 0.438 0.508 0.463 0.534 0.740			
Processing information subscale (F5)			0.9	0.75	0.801
	Pi3 Pi5 Pi6	0.484 0.539 0.483			
Test strategy subscale (F6)			0.76	0.44	0.726
	Ts1 Ts3 Ts4 W5	0.485 0.595 0.560 0.400			
Concentration & Memory subscale (F7)			0.83	0.63	0.733
	Cm4 Cm5 Cm6	0.531 0.472 0.519			
Time management subscale (F8)			0.74	0.49	0.700
	Tm4 Tm6	0.488 0.476			

	Tm7	0.428			
37-item scale					0.944

*Extraction method: Principal axis factoring. Rotation method: Varimax. Factor loading cut-off: > 0.4

Table 3.

The factor structure of an initial model extracted from SSAQ-CCHU by EFA and its internal consistency reliability

Assessment of convergent and discriminant validity

The average variance extracted (AVE) values for constructs F1, F4, F6, and F8 are less than 0.5 in **Table 3**. This indicates that the convergent validity for these constructs may not be achieved. With AVE values below 0.5, there might be some concerns about the ability of these indicators to adequately represent their corresponding constructs, and further modification of these constructs may be needed to ensure convergent validity.

In **Table 4-5**, the correlations between constructs F3-F6 and F7-F8 being greater than 0.85 suggest that there may be a lack of discriminant validity among these constructs. When the correlations between constructs are too high, it indicates that the constructs may not be sufficiently different from each other, and there might be an overlap in the measurement of these constructs. Moreover, test of Discriminant Validity based on Fornell & Larcker criterion in Table 5 showed the correlations between 8 constructs are higher or equal to the square root of AVE for each construct located on the diagonal line of the table. This finding suggests that there may be a lack of discriminant validity among the constructs to raise concerns about the distinctiveness and uniqueness of each construct in the model.

	F1	F2	F3	F4	F5	F6	F7	F8
F1	**1**							
F2	0.75	**1**						
F3	0.33	0.5	**1**					
F4	0.78	0.78	0.64	**1**				
F5	0.68	0.77	0.67	***0.85***	**1**			
F6	0.54	0.68	***0.88***	0.8	0.79	**1**		
F7	0.71	***0.85***	0.64	0.74	0.7	0.79	**1**	
F8	0.58	0.74	0.53	0.67	0.65	0.78	***0.87***	**1**

Table 4.

Matrix of correlation coefficients between constructs in the initial model

	F1	F2	F3	F4	F5	F6	F7	F8
F1	**0.71**							
F2	*0.75*	**0.77**						
F3	0.33	0.50	**0.78**					
F4	*0.78*	*0.78*	0.64	**0.70**				
F5	0.68	*0.77*	0.67	*0.85*	**0.87**			
F6	0.55	*0.68*	*0.88*	*0.8*	*0.79*	**0.67**		

F7	*0.71*	*0.85*	0.64	*0.74*	0.7	*0.79*	**0.79**	
F8	0.58	*0.74*	0.54	0.67	0.65	*0.79*	*0.87*	**0.70**

Table 5.

The square root of the average variance extracted (AVE) (in bold) and correlations between constructs (off-diagonal) used in Test of Discriminant Validity based on Fornell & Larcker criterion for the Initial Model.

Goodness-of-fit indices

Table 6 showed the result of initial model fit analysis. The absolute fit indices included $\chi 2$ = 1090.790, p- value < 0.0001 indicating a rejection of the null hypothesis of a perfect fit, Goodness of Fit Index (GFI) = 0.717, and Root Mean Square Error of Approximation (RMSEA) = 0.078, *p*-value < 0.0001 to reject the null hypothesis of model fit. The relative fit indices included Adjusted Goodness of Fit Index (AGFI) = 0.669, Comparative Fit Index (CFI) = 0.753, Incremental Fit Index (IFI) = 0.761, (Tucker-Lewis Index) TLI = 0.727, and Standardized Root Mean Square Residual) SRMR = 0.0846. These indices suggest that the model does not achieve an acceptable fit to the data.

Model fit indices	**Model fit thresholds**	**Fit indices/ initial model resulted from EFA**	**Fit indices/ final model from CFA**
Absolute fit indices			
Chi square (CMIN)		1090.790	34.196
CMIN/DF (χ^2/ df)	≤ 3 acceptable fit	1.815	1.179
Chi square			
Likelihood ratio (*p*-value)	> 0.05 acceptable fit	< 0.0001	0.232
RMSEA	≤ 0.05 excellent fit	0.078	0.037
(*p*-value)	> 0.05 acceptable fit	< 0.0001	0.653
GFI	≥ 0.95 excellent fit	0.717	0.95
	≥ 0.9 acceptable fit		
Relative fit indices			
SRMR	≤ 0.08 acceptable fit	0.0846	0.0454
AGFI	≥ 0.9 acceptable fit	0.669	0.906
IFI	> 0.95 good fit	0.761	0.990
TLI	> 0.95 good fit	0.727	0.984
CFI	≥ 0.95 excellent fit	0.753	0.990
NFI	≥ 0.9 acceptable fit	0.589	0.939
	= 1 excellent fit		
	≥ 0.9 acceptable fit		

Table 6.

Model fit indices for initial and final models

Overall, based on the analysis of the convergent and discriminant validity, and the model fit

indices, the initial model might have indicators not to ensure convergent validity, a potential lack of discriminant validity, and a misfit to the data. It is important to consider model modifications to improve the model fit. Revising the model based on the modification indices provided by the analysis may lead to a better-fitting model that adequately represents the relationships between the observed variables and latent constructs in the data.

Final Model from CFA

Model Modification

The final model was achieved through several iterations of re-specifying the model based on large modification indices (MI) greater than 20. In this process, changes were made to the model, and 17 items with low factor item loadings less than 0.6 were excluded. Additionally, ten items were deleted due to having standardized residual covariance greater than 2 and non-significant paths. Furthermore, five factors (F3, F4, F6, F7, and F8) were excluded from the model as they did not have at least 3 items per construct, which is a common rule of thumb for maintaining construct validity and reliability. After these revisions, the final model consisted of three factors: motivation and attitude (F1), test strategy and comprehension (F2), and processing information (F5) with a total of 10 items in the Appendix B. The variance estimates for each factor were 0.235, 0.223, and 0.243, respectively. Parameter estimates of the final model are shown in **Figure 2.**

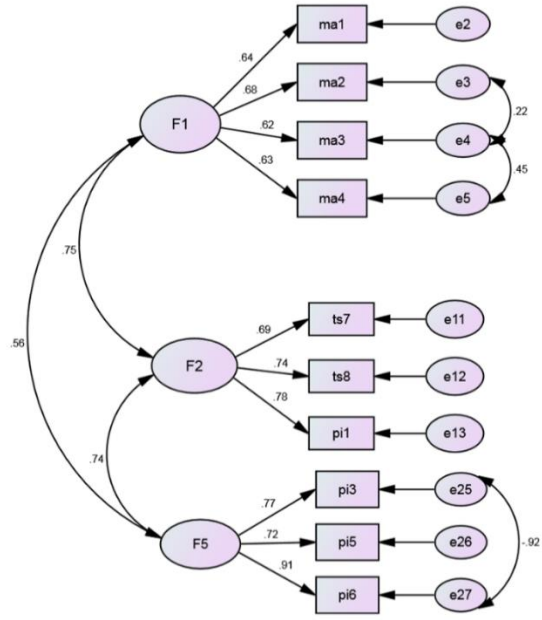

Figure 2. Improved Model of Study Skills

Assessment of construct reliability

Table 7 presents the overall Cronbach's alpha value of 0.864, which indicates good internal consistency and acceptable reliability of the data (Diseth et al., 2010; Hair et al., 2010). Moreover, each individual construct also demonstrated strong internal consistency, as

evidenced by both Cronbach's alpha values and composite reliability (CR) exceeding the recommended threshold of 0.7. These high values suggest that the observed items within each construct are consistently measuring the same underlying construct.

Factor	Standardized factor loadings	Variance Estimate	AVE (> 0.5)	CR (> 0.7)	Cronbach's alpha (> 0.7)
Motivation and attitude (F1)		0.235***	0.54	0.82	0.793
Ma1	0.64				
Ma2	0.68				
Ma3	0.62				
Ma4	0.63				
Test strategy and comprehension (F2)		0.223***	0.73	0.86	0.779
Ts7	0.69				
Ts8	0.74				
Pi1	0.78				
Processing information (F5)		0.243***	0.82	0.91	0.782
Pi3	0.77				
Pi5	0.72				
Pi6	0.91				
10-item scale					0.864

*** Variance estimate for factor is significantly different from 0 at the 0.001 level

Table 7.

The factor structure of final model, and results of convergent validity and construct reliability tests

Assessment of convergent and discriminant validity

Table 7 reveals that the Average Variance Extracted (AVE) values for three constructs are greater than 0.5, indicating that convergent validity for these constructs is likely achieved, and indicators are converging and effectively capturing the underlying construct (Hattie, Biggs, & Purdie, 1996).

In **Table 8**, the correlations between constructs F1, F2, and F5 are found to be lower than 0.85, which indicates the presence of discriminant validity among these constructs (Hsin & Cigas, 2013). Lower correlations between these constructs suggest that they are separate and distinct entities, supporting the presence of discriminant validity. Furthermore, the test of discriminant validity based on the Heterotrait-Monotrait (HTMT) ratio criterion in **Table 9** reveals that the HTMT ratios for the three constructs in the final model are less than 0.85 (Hung & Nguyen,

2022). This finding further supports the presence of discriminant validity among the constructs. The HTMT ratio is an effective method to assess discriminant validity, with values close to 1 suggesting a lack of discriminant validity, while values below 0.85 indicate distinct and discriminable constructs.

	Motivation & attitude	Test strategy & comprehension	Processing information
Motivation & attitude	1.00		
Test strategy & comprehesion	0.75	1.00	
Processing information	0.56	0.74	1.00

Table 8.

Matrix of correlation coefficients between constructs in the final model

Constructs	F1	F2	F5
F1(Motivation & attitude)			
F2 (Test strategy & comprehension)	0.69		
F5 (Processing information)	0.56	0.79	

Table 9.

Heterotrait – monotrait ratio between constructs in the final model

In summary, the results from **Table 7**, **Table 8**, and **Table 9** collectively indicate that the measurement model demonstrates good convergent validity for three constructs and also exhibits discriminant validity among the constructs F1, F2, and F5.

Goodness-of-fit indices

The absolute fit indices for the model in Table 6 indicate that the chi-square value ($\chi 2$) is 34.196 with a *p*-value of 0.232, suggesting that the null hypothesis of a perfect fit is accepted (Fereidouni & Abolfazli Khonamri, 2015). The Goodness of Fit Index (GFI) is 0.95, and the Root Mean Square Error of Approximation (RMSEA) is 0.037 with a *p*-value of 0.232, indicating that the null hypothesis of model fit is also accepted (Fryer & Elliot, 2007; García & Doménech, 2010). These absolute fit indices collectively suggest that the model fits the data well.

The relative fit indices include the Adjusted Goodness of Fit Index (AGFI) of 0.906, the Comparative Fit Index (CFI) of 0.990, the Incremental Fit Index (IFI) of 0.990, the Tucker-Lewis Index (TLI) of 0.984, and the Standardized Root Mean Square Residual (SRMR) of 0.045 (Gaspar et al., 2016; George & Mallery, 2019). These indices further support a good fit of the model to the data. The AGFI, CFI, and IFI values close to 1 indicate a high level of fit, while the TLI value of 0.984 and the SRMR value of 0.045 suggest a very good fit to the data.

In summary, the measurement model in this study demonstrates strong convergent and discriminant validity, reliability, and a good fit to the data. The high factor loadings, composite reliability, and average variance extracted (AVE) values for each construct indicate that the observed items consistently measure the intended construct. HTMT ratios below 0.85 for the

three constructs provides support for the discriminant validity of the measures to effectively capture distinct aspects of the scale. Moreover, the high values of Cronbach's alpha and composite reliability support the internal consistency and reliability of the data. The acceptable level of fit based on both absolute and relative fit indices further reinforces the effectiveness of the proposed measurement model in assessing study skills. Overall, the assessment tool provides a credible and accurate means to evaluate the study skills of public health students during the post-COVID-19 new normal era.

Differences between public health students across three factors of modified CFA model

The Mann-Whitney and Kruskal Wallis tests revealed interesting results in terms of the student groups based on gender, age, major, and years of study, across the three constructs of study skills. The study found that gender had a significant impact on motivation and attitude toward active learning in class; male students were more likely to engage in active learning compared to female students. Additionally, the research indicates that community public health students may be better at organizing information and using it to solve problems compared to students in other majors. However, no statistically significant differences in study skills were identified across the remaining groups **(Table 10).**

Grouping variables	Motivation and attitude	Test strategy and comprehension	Processing information
Age[1]			
Chi-square	3.78	0.501	3.156
p-value	0.437	0.973	0.532
Year of study[1]			
Chi-square	1.516	0.925	3.29
p-value	0.679	0.819	0.349
Major of study[1]			
Chi-square	2.139	4.041	8.213
p-value	0.343	0.133	**0.016**
Gender[2]			
Z	-2.564	-1.738	-0.845
p-value	**0.01**	0.082	0.398

[1] Kruskal Wallis test; [2] Mann-Whitney test

Table 10.

Differences in motivation and attitude (F1), test strategy and comprehension (F2), and organizing information (F5) between students groups of demographic characteristics

Discussion

This study developed and validated an enhanced SSAQ-CCHU scale to assess study skills among public health students in the post-COVID-19 educational landscape. Initially, an 8-factor model derived from EFA explained 53.36% of variance but required refinement due to suboptimal convergent/discriminant validity and fit indices. Model re-specification via CFA—removing non-significant paths, adding error covariances, and eliminating items with low loadings (< 0.6) or high residuals—yielded a robust 3-factor structure (10 items): Motivation and Attitude, Test Strategy and Comprehension, and Processing Information (García &

Doménech, 2010). The final model demonstrated strong validity: Convergent Validity: AVE > 0.5, CR > 0.7, and factor loadings > 0.6 (Hair et al., 2010). Discriminant Validity: HTMT ratios < 0.85 and Fornell-Larcker criterion confirmed distinct constructs (Hsin & Cigas, 2013). Fit Indices: $\chi^2/df = 34.19$ ($p > 0.05$), RMSEA = 0.037, GFI = 0.95, CFI = 0.99, SRMR = 0.045 (Hsin & Cigas, 2013). Reliability: Cronbach's $\alpha \geq 0.7$ for all constructs (Diseth et al., 2010). These constructs assume a paramount role in fostering students' study skills amid the post-COVID-19 new normal era because the recent studies revealed students decreased motivation and interest in learning after the COVID-19 pandemic. Hence, the papers suggested that students need to develop necessary skills to adapt to the new normal era (Hung & Nguyen, 2022; Hussin et al., 2019; Joynes et al., 2019; Kaur & Sharma, 2014) because study skills impact the academic performance of students (Khajehpour & Ghazvini, 2011).

Core constructs in the post-pandemic context

Motivation and attitude

Motivation emerged as the cornerstone of academic resilience, driving proactive behaviors like optimizing learning environments (e.g., seating choices), active class participation, and goal-setting. Post-pandemic, students face hybrid models requiring intrinsic drive to balance autonomy and structure (Kintsch, 1998; Komarraju et al., 2010). Motivated learners exhibit enhanced self-regulation, crucial for online engagement and mitigating distractions (Kröner & Hussmann, 2021; Leaver et al., 2005; Leong et al., 2020). This aligns with global findings emphasizing motivation's role in sustaining academic performance amid disruptions (Hung & Nguyen, 2022; Hussin et al., 2019; Joynes et al., 2019; Kaur & Sharma, 2014).

Test Strategy and Comprehension

This construct integrates composure during exams, familiarity with diverse formats (e.g., online assessments), and discernment of key concepts. Test strategy and comprehension skills were found to be instrumental in guiding students towards effective ways of answering questions and achieving better scores, even in the absence of prior knowledge (Liu & Liu, 2011). Thus, foundational knowledge remains vital, and strategic skills enable students to maximize performance within knowledge limits (Liu & Liu, 2011; Nasir & Yusoff, 2019). Moreover, post-COVID education emphasizes varied assessments, necessitating strategic preparation and adaptability (O'Neill, 2023). The shift toward self-directed learning further underscores the need for mastery of test structures and critical content identification (Paivandi & Pourghaz, 2014).

Processing Information

Critical thinking, material organization, and concept breakdowns define this construct. These skills are vital in hybrid settings, where students must evaluate digital resources and synthesize information independently (Pekrun, 2006; Pintrich et al., 1994). Post-pandemic curricula increasingly prioritize critical thinking as a 21st-century competency, with universities adopting interventions like video-based learning to enhance these skills (Rafoth & DeFabo, 2005; Tan et al., 2023; Forbes, 2018; Tan et al., 2023; Ebrahimi, 2023). Effective information processing supports retention and application, particularly in self-directed contexts (Zimmerman, 1989).

Regarding group differences in study skills, statistically significant differences were observed between male and female students in the construct of motivation/attitude. Males reported higher motivation/attitude scores, potentially reflecting cultural norms encouraging assertiveness in

Asian contexts (Kamel et al., 2020). Furthermore, compared with occupational and environmental health students, community public health (CPH) students excelled in information processing, likely due to training in problem-solving and data application for community health issues.

Limitations

The limitation posed by the lack of gender stratification. The lack of gender-specific analysis limits insights into divergent learning strategies. Future studies should explore gender-based differences to inform equitable support frameworks.

Next, the absence of alternative model comparisons restricts the validation of the proposed model's effectiveness against alternative frameworks, limiting the robustness of findings. Comparative analyses could strengthen methodological rigor.

Finally, further testing across diverse contexts is needed to ensure cross-cultural applicability and cultural generalizability.

Conclusion

This study advances the assessment of study skills by validating a concise, contextually relevant SSAQ-CCHU scale. The identified constructs—Motivation and Attitude, Test Strategy and Comprehension, and Processing Information—are pivotal for academic success in evolving educational landscapes. Educators and policymakers can leverage these insights to design targeted interventions, fostering resilience and adaptability. Future research should expand demographic analyses, incorporate model comparisons, and evaluate evidence-based skill-building programs through randomized trials.

Ethical Approval

The study protocol and informed consent have been reviewed and approved by the Ethics Committee in Human Research at Walailak University (WUEC-22-192-01), based on the Declaration of Helsinki. Potential study participants received a thorough explanation of the investigation and assurances of confidentiality. Each participant signed written, informed consent before taking part. Additionally, they were made aware of the study's voluntary nature and that participating in it would not have any negative effects.

Competing Interests

The author has no financial or non-financial interests that could be perceived as influencing author’s objectivity in this research. The author has taken into consideration any relationships, affiliations, knowledge, or beliefs that could potentially affect the results of this study.

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Appendix A

Study Skills Assessment Questionnaireof the Counseling Center of Houston University (SSAQ-CCHU)

The Study Skills Assessment Questionnaire is divided into 8 sections. Each section has 8 items and an assessment that usually takes less than 10 minutes to complete:

Assessment
Use the scale below to indicate how often each statement applies to you:
1 = Never 2 = Sometimes 3 = Usually 4 = Always

Section 1: Time Management and Procrastination
Time 1: I arrive at classes and other meetings on time.
Time 2: I devote sufficient study time to each of my courses.
Time 3: I schedule definite times and outline specific goals for my study time.
Time 4: I prepare a "to do" list daily.
Time 5: I avoid activities which tend to interfere with my planned schedule.
Time 6: I use prime time when I am most alert for study.
Time 7: At the beginning of the term, I make up daily activity and study schedules.
Time 8: I begin major course assignments well in advance

Section 2: Concentration and Memory

Cm 1: I have the "study-place habit," that is, merely being at a certain place at a certain time means time to study.
Cm 2: I study in a place free from auditory and visual distractions.
Cm 3: I find that I am able to concentrate - that is, give undivided attention to the task for at
least 20 minutes.
Cm 4: I am confident with the level of concentration I am able to maintain.
Cm 5: I have an accurate understanding of the material I wish to remember.
Cm 6: I learn with the intention of remembering.
Cm 7: I practice the materials I am learning by reciting out loud.
Cm 8: I recall readily those things which I have studied.

Section 3: Study Aids and Note-Taking
Sa 1: While I am taking notes I think about how I will use them later.
Sa 2: I understand the lecture and classroom discussion while I am taking notes.
Sa 3: I organize my notes in some meaningful manner (such as outline format).
Sa 4: I review and edit my notes systematically.
Sa 5: I take notes on supplementary reading materials.
Sa 6: I have a system for marking textbooks.
Sa 7: When reading, I mark or underline parts I think are important.
Sa 8: I write notes in the book while I read.

Section 4: Test Strategies and Test Anxiety
Ts 1: I try to find out what the exam will cover and how the exam is to be graded.
Ts 2: I feel confident that I am prepared for the exam.
Ts 3: I try to imagine possible test questions during my preparation for an exam.
Ts 4: I take time to understand the exam questions before starting to answer.
Ts 5: I follow directions carefully when taking an exam.
Ts 6: I usually get a good night's rest prior to a scheduled exam.
Ts 7: I am calmly able to recall what I know during an exam.
Ts 8: I understand the structure of different types of tests, and am able to prepare for each
Type

Section 5: Organizing and Processing Information
Pi 1: When reading, I can distinguish readily between important and unimportant points.
Pi 2: I break assignments into manageable parts.
Pi 3: I maintain a critical attitude during my study - thinking before accepting or rejecting.
Pi 4: I relate material learned in one course to materials of other courses.
Pi 5: I try to organize facts in a systematic way.

Pi 6: I use questions to better organize and understand the material I am studying.
Pi 7: I try to find the best method to do a given job.
Pi 8: I solve a problem by focusing on its main point.

Section 6: Motivation and Attitude
Ma 1:I sit near the front of the class if possible.
Ma 2: I am alert in classes.
Ma 3: I ask the instructor questions when clarification is needed.
Ma 4: I volunteer answers to questions posed by instructors in the class.
Ma 5: I participate in meaningful class discussions.
Ma 6: I attend class regularly.
Ma 7: I take the initiative in group activities.
Ma 8: I use a study method which helps me develop an interest in the material to be studied.

Section 7: Reading and Selecting the Main Idea
Sm 1: I survey each chapter before I begin reading.
Sm 2: I follow the writer's organization to increase meaning.
Sm 3: I review reading material several times during a semester.
Sm 4: When learning a unit of material, I summarize it in my own words.
Sm 5: I am comfortable with my reading rate.
Sm 6: I look up parts I don't understand.
Sm 7: I am satisfied with my reading ability.
Sm 8: I focus on the main point while reading.

Section 8: Writing
W 1: I find that I am able to express my thoughts well in writing.
W 2: I write rough drafts quickly and spontaneously from notes.
W 3: I put aside a written assignment for a day or so, then rewrite it.
W 4: I review my writing for grammatical errors.
W 5: I have someone else read my written work and consider their suggestions for improved writing.
W 6: I am comfortable using library resources for research.
W 7: I am able to narrow a topic for an essay, research paper, etc.
W 8: I allow sufficient time to collect information, organize material, and write the assignment.

Appendix B

The study skill assessment questionnaires improved from SSAQ-CCHU to fit the context of post-COVID-19 new normal era

Motivation

Ma 1:I sit near the front of the class if possible.
Ma 2: I am alert in classes.
Ma 3: I ask the instructor questions when clarification is needed.
Ma 4: I volunteer answers to questions posed by instructors in the class.

Test strategy and comprehension

Ts 7: I am calmly able to recall what I know during an exam.
Ts 8: I understand the structure of different types of tests, and am able to prepare for each
type
Pi 1: When reading, I can distinguish readily between important and unimportant points.

Processing information

Pi 3: I maintain a critical attitude during my study - thinking before accepting or rejecting.
Pi 5: I try to organize facts in a systematic way.
Pi 6: I use questions to better organize and understand the material I am studying.
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