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Research Skills Scale for Undergraduate Students (RSS-UG): Development and Validation Using Exploratory and Confirmatory Factor Analysis

Queenne Kimverlee C. Landingin, MAN, MSN, MAED[1*], and Jose Marsan Marcos
[1] *University of La Salette, Inc., Santiago City, Isabela, Philippines*
[*] *kim01079157@gmail.com*

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ABSTRACT

This study developed and validated the Research Skills Scale for Undergraduate Students (RSS-UG), a self-report instrument measuring five dimensions of research skills aligned with the stages of the research process. Guided by Creswell's research process and Willison and O'Regan's Research Skill Development (RSD) framework, an initial pool of 80 items was written for five constructs: research conceptualization, literature review, formulation of research methodology, data analysis, and summary, conclusions, and recommendations. Five experts rated item relevance in two rounds; two items were deleted and six were revised, yielding 78 items with I-CVI = 1.00 and S-CVI/Ave = 1.00. A pilot test with 40 students removed three items. Exploratory factor analysis (EFA) on 400 students from one school (KMO = 0.955) supported five factors by parallel analysis and retained 57 items explaining 53.8% of the variance. Confirmatory factor analysis (CFA) on an independent sample of 326 students from three other schools confirmed the five-factor model ($\chi^2/df = 1.41$, CFI = 0.962, TLI = 0.961, RMSEA = 0.029, SRMR = 0.036), which fit significantly better than a one-factor model. Reliability was high for all dimensions (Cronbach's $\alpha = 0.906–0.937$; composite reliability = 0.908–0.939) and for the full scale ($\alpha = 0.966$). Discriminant validity was supported by the Fornell-Larcker criterion and HTMT ratios below 0.85. The RSS-UG is a valid and reliable instrument for assessing undergraduate research skills and for guiding research instruction. The scale follows the sequence of undergraduate thesis work and provides dimension scores that can help instructors identify areas requiring instructional support. Further validation should examine performance-based evidence and measurement invariance across student groups.

Keywords: *research skills, undergraduate students, scale development, exploratory factor analysis, confirmatory factor analysis*

INTRODUCTION

Research skills are a core outcome of higher education. They allow students to identify problems, locate and evaluate evidence, collect and analyze data, and communicate defensible conclusions (Willison & O'Regan, 2007). In the Philippines, many undergraduate programs require students to complete a research course or thesis before graduation, which makes research skills both a learning goal and a graduation requirement. Yet completing a thesis does not guarantee that students have developed the underlying skills. The same gap reaches the faculty who guide them: at a university in Northern Philippines, inadequate research skills, heavy teaching loads, and lack of time were among the main deterrents to faculty research (Landingin et al., 2024).

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Studies across countries report persistent gaps. Undergraduates in India showed large differences between the information-seeking and methodological skills they considered necessary and those they actually had (Banu et al., 2022). Nursing thesis students in Peru reached developed levels in instrumental skills but remained in the process of development in problematization and epistemological skills, and they rarely used Boolean operators (Correa-Sánchez & Ruiz-Aquino, 2025). Senior pre-service teachers in the Philippines rated their skills as very satisfactory overall but struggled with hypothesis formulation, conceptual frameworks, and statistical analysis (de Guzman, 2024).

Measuring these skills accurately requires instruments with sound psychometric evidence. Several existing scales, however, have limitations for undergraduate use. Berrocal's (2019) scale, used by Correa-Sánchez and Ruiz-Aquino (2025), was developed for postgraduate students and organizes skills by type (epistemological, problematization, methodological, instrumental) rather than by research stage. Lacson and Dejos (2022) developed a scale for senior high school students through content validation and EFA, but they did not conduct a CFA and recommended one for future studies. Daryanes et al. (2025) applied both EFA and CFA, but their instrument targets pre-service biology teachers and follows the RSD facets, which overlap considerably in practice.

No published instrument, to the researcher's knowledge, measures undergraduate research skills across the full sequence of a research study, from conceptualization to recommendations, with evidence from both EFA and CFA on independent samples. Notably, the summary, conclusions, and recommendations stage is rarely measured as a separate dimension, even though drawing evidence-based conclusions is a key research outcome. This study addresses that gap by developing and validating the Research Skills Scale for Undergraduate Students (RSS-UG).

Research Objectives

This study aimed to develop and validate an instrument that measures the research skills of undergraduate students. Specifically, it sought to:

1. Establish the content validity of the RSS-UG through expert evaluation.
2. Refine the items through pilot testing.
3. Determine the factor structure of the RSS-UG through exploratory factor analysis.
4. Confirm the factor structure on an independent sample from other schools through confirmatory factor analysis.
5. Establish the reliability, convergent validity, and discriminant validity of the final scale.

Theoretical Framework

This study is anchored on Creswell's research process (Creswell & Guetterman, 2019) and the Research Skill Development (RSD) framework of Willison and O'Regan (2007).

Creswell describes research as a sequence of steps: identifying a research problem, reviewing the literature, specifying a purpose, collecting data, analyzing and interpreting data, and reporting and evaluating research. Because undergraduates experience research as these steps in their thesis, the RSS-UG organizes skills by stage. Identifying the problem and specifying the purpose form *research conceptualization*; reviewing the literature forms *literature review*; planning data collection forms *formulation of research methodology*; analyzing and interpreting data forms *data analysis*; and reporting and evaluating form *summary, conclusions, and recommendations*.

The RSD framework describes six facets of research (embark and clarify, find and generate, evaluate and reflect, organize and manage, analyze and synthesize, and communicate and apply) that students develop along a continuum of increasing autonomy (Willison & O'Regan, 2007). The RSD facets supply the cognitive skills within each stage. Critical-reflective thinking, which Berrocal (2019) calls the epistemological dimension, is embedded across the stages, particularly in appraising sources and drawing evidence-based conclusions.

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Table 1. *Alignment of the RSS-UG dimensions with Creswell's process and the RSD facets*

RSS-UG dimension	Creswell's research process step	Main RSD facets
Research Conceptualization (RC)	Identifying a research problem; specifying a purpose	Embark and clarify
Literature Review (LR)	Reviewing the literature	Find and generate; evaluate and reflect; analyze and synthesize
Formulation of Research Methodology (RM)	Collecting data (planning)	Find and generate; organize and manage
Data Analysis (DA)	Analyzing and interpreting data	Organize and manage; analyze and synthesize
Summary, Conclusions, and Recommendations (SCR)	Reporting and evaluating research	Evaluate and reflect; communicate and apply

METHODS

Research Design

This study used an instrument development design following Creswell's exploratory sequential approach (Creswell & Plano Clark, 2018) and the scale development steps of DeVellis and Thorpe (2022). The study had two phases: a development phase (literature review, item generation, expert validation, and pilot testing) and a validation phase (EFA, CFA, and reliability and validity analysis).

Participants

Participants were undergraduate students enrolled in a research course or thesis during the academic year 2026–2027. Inclusion criteria were enrollment in third or fourth year, current or completed enrollment in a research course, and with voluntary consent. Three independent groups were used.

Table 2. *Study samples in Every Phase and Schools*

Phase	Schools	n	Purpose
Pilot test	School A	40	Item clarity and preliminary reliability
EFA	School A	400	Exploring the factor structure
CFA	School B (133), C (80), and D (113)	326	Confirming the structure in other schools

Pilot participants were excluded from the EFA sample. The EFA sample met the guideline of at least 5 respondents per item, and the CFA sample exceeded the commonly recommended minimum of 200 (Hair et al., 2019).

Research Instrument

The initial RSS-UG contained 80 items, 16 per dimension, answered on a 5-point frequency scale: 1 (never), 2 (rarely), 3 (sometimes), 4 (often), and 5 (always). Items were written as single, positively worded behavioral statements (e.g., "I identify the research gap from the literature I reviewed"). Some items were adapted from Berrocal (2019) and Lacson and Dejos (2022); the rest were newly written.

Procedures

Development phase

The researcher reviewed the literature on research skills and existing instruments, defined the five constructs, and generated the item pool. Five experts (research methods faculty, thesis advisers, a psychometrician, and a research coordinator) rated each item's relevance on a 4-point scale (1 = not relevant to 4 = highly relevant). The item-level content validity index (I-CVI), scale-level indices (S-CVI/Ave and S-CVI/UA), and modified kappa were computed. Because it had five experts, the I-CVI criterion was 1.00

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(Lynn, 1986); items below this were revised and re-rated in a second round. The revised instrument was pilot tested with 40 students, eight of whom took part in cognitive interviews.

Validation phase

The instrument was administered face-to-face and through Google Forms to the EFA sample at School A. After the EFA, the reduced instrument was administered to the CFA sample at Schools B, C, and D.

Data Analysis

***Content validity*:** I-CVI, S-CVI/Ave, S-CVI/UA, and modified kappa (Polit et al., 2007).

***Pilot test*:** corrected item-total correlations (CITC) and Cronbach's alpha. Items with CITC below 0.30 that students also reported as problematic were deleted.

***EFA*:** sampling adequacy was assessed with the Kaiser-Meyer-Olkin (KMO) test (≥ 0.70) and Bartlett's test of sphericity ($p < .05$). The number of factors was determined by parallel analysis (Horn, 1965). Principal axis factoring with promax rotation was used. Items were removed one at a time if their highest loading was below 0.50 or if they cross-loaded (second loading ≥ 0.30 and within 0.20 of the primary loading).

***CFA*:** a correlated five-factor model was tested and compared with a one-factor model. Fit criteria were $\chi^2/df \leq 3.00$, CFI and TLI ≥ 0.95, RMSEA ≤ 0.06, and SRMR ≤ 0.08 (Hu & Bentler, 1999).

***Reliability and validity*:** Cronbach's alpha, McDonald's omega, and composite reliability (CR) ≥ 0.70; average variance extracted (AVE) ≥ 0.50 for convergent validity; and the Fornell-Larcker criterion (Fornell & Larcker, 1981) and HTMT ratios < 0.85 (Henseler et al., 2015) for discriminant validity.

Analyses were conducted in Jeffreys's Amazing Statistics Program (JASP).

Ethical Considerations

Participants gave informed consent, participation was voluntary, and responses were anonymous and confidential.

RESULTS

Content Validity

In Round 1, 72 of the 80 items were rated relevant by all five experts (I-CVI = 1.00, modified kappa = 1.00). Six items were rated relevant by four experts (I-CVI = 0.80, kappa = 0.76) and two by three experts (I-CVI = 0.60, kappa = 0.42). Round 1 scale-level indices were S-CVI/Ave = 0.975 and S-CVI/UA = 0.90.

Table 3. *Items deleted or revised after round 1 of Experts Review*

Code	Original item	I-CVI	Decision
RC10	I justify my research topic based on theory.	0.60	**Deleted**
SCR10	I explain the implications of my findings for theory.	0.60	**Deleted**
RC16	I check whether my research problem is feasible given the available time and resources.	0.80	Revised
LR5	I prioritize peer-reviewed sources over non-academic sources.	0.80	Revised
LR12	I compare the findings of previous studies on my topic.	0.80	Revised

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RM4	I identify the differences between research approaches.	0.80	Revised
DA5	I classify collected data according to its level of measurement.	0.80	Revised
SCR14	I direct my recommendations to specific stakeholders.	0.80	Revised

The experts judged the two deleted items too advanced for undergraduates, since theory-building is rarely expected in an undergraduate thesis. The six revised items were reworded to be more concrete (revised wording appears in Appendix C).

In Round 2, all five experts rated the revised items as relevant, so the 78-item version reached I-CVI = 1.00 for every item and S-CVI/Ave = S-CVI/UA = 1.00, meeting Lynn's (1986) criterion for a five-member panel.

Pilot Test

Forty students completed the 78-item version in about 20 minutes. Dimension alphas ranged from 0.894 to 0.932.

Table 4. *Pilot test reliability (n = 40)*

Dimension	Items	Cronbach's α	Items with CITC < 0.30	Deleted	α after deletion
RC	15	0.894	RC1, RC9	None	0.894
LR	16	0.902	LR3, LR6	LR3	0.915
RM	16	0.932	None	None	0.932
DA	16	0.923	DA1, DA3, DA11	DA11	0.928
SCR	15	0.924	SCR8	SCR8	0.937

Three items were deleted because they combined low CITC with problems reported in cognitive interviews. Students could not answer LR3 (Boolean operators) because most had never used them, consistent with the limited Boolean operator use among thesis students reported by Correa-Sánchez and Ruiz-Aquino (2025). Students in qualitative or descriptive studies said DA11 (interpreting p-values) and SCR8 (hypotheses supported) did not apply to their research. The other low-CITC items were retained for the EFA because correlations from 40 respondents are unstable. The 75-item version was used in the EFA.

Exploratory Factor Analysis

The data were suitable for factor analysis. KMO was 0.955, classified as marvelous (Kaiser, 1974), and Bartlett's test of sphericity was significant, $\chi^2(2775) = 15402.14$, $p < .001$. No item had a mean close to 1 or 5.

Parallel analysis supported five factors. The first five eigenvalues (21.17, 4.51, 4.15, 3.35, and 2.32) exceeded the 95th percentile of eigenvalues from random data, while the sixth (1.30) fell below its random value of 1.75 (Figure 1). The eigenvalue-greater-than-one rule would have retained ten or more factors, which illustrates why parallel analysis is preferred for determining the number of factors.

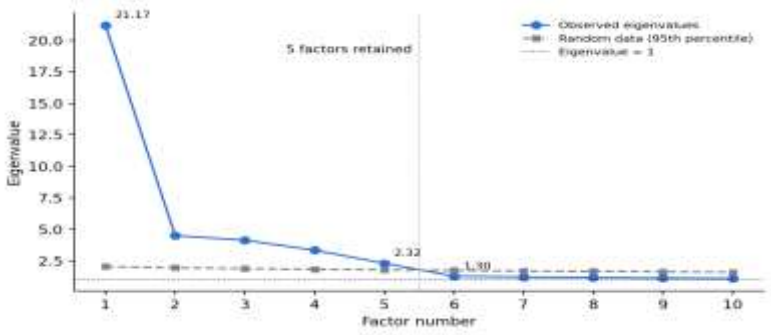

Figure 1. *Scree plot with parallel analysis (EFA sample, n = 400, 75 items)*

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Eighteen items were removed in successive EFA runs: 17 had loadings below 0.50 (LR1, DA14, DA1, RM16, RC1, LR6, DA3, LR2, RC5, RC15, RC9, RM14, SCR4, RM8, SCR15, SCR3, and LR15), and RM5 cross-loaded on research conceptualization.

The final 57 items loaded cleanly on five factors that explained 53.8% of the total variance (KMO = 0.958).

Table 5. *Final EFA solution (57 items)*

Factor	Items	Primary loading range	Highest cross-loading
Research Conceptualization (RC)	11	0.53–0.81	0.12
Literature Review (LR)	11	0.65–0.81	0.12
Formulation of Research Methodology (RM)	12	0.57–0.80	0.15
Data Analysis (DA)	12	0.51–0.82	0.29
Summary, Conclusions, and Recommendations (SCR)	11	0.51–0.79	0.12

Table 6. *EFA factor correlation matrix*

Factor	RC	LR	RM	DA	SCR
RC	1.00				
LR	0.46	1.00			
RM	0.47	0.47	1.00		
DA	0.34	0.47	0.49	1.00	
SCR	0.45	0.48	0.38	0.54	1.00

The factors were moderately correlated (0.34 to 0.54), lower than the correlations of 0.65 to 0.77 among Lacson and Dejos's (2022) three factors.

Confirmatory Factor Analysis

The CFA tested whether the five-factor structure found at school A holds in different schools. The 57-item correlated five-factor model fit the data from Schools B, C, and D well on every index.

Table 7. *Model fit of the five-factor and one-factor models (n = 326)*

Model	χ^2	df	χ^2/df	CFI	TLI	RMSEA	SRMR
Five correlated factors	2163.22	1529	1.41	0.962	0.961	0.029	0.036
One general factor	8080.16	1539	5.25	0.610	0.596	0.092	—
Criterion			≤ 3.00	≥ 0.95	≥ 0.95	≤ 0.06	≤ 0.08

Although the chi-square test was significant, as expected with large samples, χ^2/df, CFI, TLI, RMSEA, and SRMR all met the criteria for good fit (Hu & Bentler, 1999). The five-factor model also fit significantly better than the one-factor model, $\Delta\chi^2(10) = 5916.94$, $p < .001$, so research skills are better represented as five related dimensions than as one general skill. All 57 standardized loadings were significant ($p < .001$) and ranged from 0.55 to 0.90 (Appendix C).

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Reliability and Convergent Validity

Table 8. *Reliability and convergent validity (n = 326)*

Dimension	Items	α	ω	CR	AVE
Research Conceptualization	11	0.925	0.925	0.925	0.531
Literature Review	11	0.929	0.930	0.930	0.548
Formulation of Research Methodology	12	0.924	0.925	0.925	0.508
Data Analysis	12	0.937	0.939	0.939	0.564
Summary, Conclusions, and Recommendations	11	0.906	0.908	0.908	**0.475**
Total scale	**57**	**0.966**			

All dimensions exceeded 0.90 on alpha, omega, and CR, and the full scale reached α = 0.966, comparable to the 0.968 reported by Lacson and Dejos (2022). Four dimensions had AVE above 0.50.

Discriminant Validity

Table 9. *Fornell-Larcker criterion (√AVE on the diagonal, factor correlations below)*

Dimension	RC	LR	RM	DA	SCR
RC	**0.728**				
LR	0.56	**0.740**			
RM	0.56	0.61	**0.713**		
DA	0.48	0.50	0.63	**0.751**	
SCR	0.52	0.61	0.56	0.64	**0.689**

Each dimension's √AVE was larger than its correlations with the other dimensions, satisfying the Fornell-Larcker criterion. In addition, all heterotrait-monotrait (HTMT) ratios were below the conservative threshold of 0.85 (Henseler et al., 2015). The five dimensions therefore measure distinct aspects of research skills.

DISCUSSION

Like Lacson and Dejos (2022), who removed two items through content validation, this phase eliminated items experts considered unnecessary; the present study additionally used a second round so that revised items were re-evaluated rather than accepted on assumption.

Unlike Lacson and Dejos (2022), whose five intended constructs collapsed into three factors, every RSS-UG item loaded on its intended dimension, so the original five constructs were retained.

This indicates that the five dimensions belong to a common research-skills construct yet remain distinguishable. The strongest correlation, between data analysis and summary, conclusions, and recommendations (0.54), is consistent with the research process, since conclusions are drawn directly from the results of the analysis.

The AVE of summary, conclusions, and recommendations (0.475) was slightly below 0.50, but convergent validity is still considered adequate when CR exceeds 0.60 (Fornell & Larcker, 1981). This dimension is newly measured as a separate construct, so its items may be refined in future studies.

This CFA extends earlier work. Lacson and Dejos (2022) validated their scale through EFA alone and recommended CFA as the next step, while Daryanes et al. (2025) confirmed a four-factor structure but within a single program at universities in one province. Confirming the RSS-UG structure in three schools other than the development site provides stronger evidence that the dimensions are not specific to one institution.

Taken together, these results support the RSS-UG as a five-dimension measure that follows the stages of the research process. The separate summary, conclusions, and recommendations dimension is a

notable contribution: in Lacson and Dejos (2022), conclusion and recommendation items merged into a broader writing-and-reporting factor, and in de Guzman (2024) they were part of communication and language use. Measuring this stage separately allows instructors to see whether students can draw evidence-based conclusions, not only write them.

Limitations

The RSS-UG relies on self-report, which may be affected by over- or underestimation of one's own skills. The samples came from four schools in Santiago City, Isabela, Philippines, which may limit generalizability. Finally, items on Boolean operators and p-value interpretation were removed because they did not apply to all students, so these specific skills may need separate assessment.

CONCLUSION

This study developed and validated the Research Skills Scale for Undergraduate Students (RSS-UG), a 57-item instrument measuring five dimensions of research skills: research conceptualization (11 items), literature review (11 items), formulation of research methodology (12 items), data analysis (12 items), and summary, conclusions, and recommendations (11 items). Content validity was established by five experts, the factor structure was identified through EFA at one school, and the structure was confirmed through CFA at three other schools. The scale showed high reliability and adequate convergent and discriminant validity. The RSS-UG can therefore be used to assess undergraduate students' research skills and to identify which stages of the research process need more instructional support.

Recommendations

Based on the findings, several recommendations are offered. Research instructors and thesis advisers may administer the RSS-UG at the start of a research course to diagnose students' research skills and again at the end to measure their growth. Program heads, curriculum developers, and institutional research officers may use the dimension scores to target instruction where students are weakest, for example through workshops on literature synthesis or statistical analysis.

For future research, studies may test the measurement invariance of the RSS-UG across sex, program, and research approach (quantitative or qualitative), and examine its test-retest reliability. Because self-report measures perceived rather than demonstrated skill, future studies may also gather criterion-related validity evidence by correlating RSS-UG scores with thesis grades or performance-based assessments. The summary, conclusions, and recommendations dimension may be refined with additional items to raise its AVE above 0.50. Finally, the scale may be validated in other regions and in both private and public institutions to broaden its generalizability.

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