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Research article

Research skills for university students' thesis in E-learning: Scale development and validation in Peru

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ABSTRACT

Background: The aims of the study was to evaluate the psychometric properties and to characteristics of a scale on research skills as well as to characterize the experience of university thesis students using information databases (i.e., Scopus or Web of Science) and bibliographic reference managers.
Methods: A sample of 1598 university students from five departments, acroos the different campuses of one Peruvian university. The psychometric properties of the instrument were evaluated using factor analysis and measurement invariance according to sex and age groups. In addition, an internal consistency analysis was conducted for scale reliability using Cronbach's alpha, ordinal alpha, and the omega index.
Results: Our study identified that the unidimensional model with correlated errors showed adequate indicators of reliability and goodness of fit, with the exception of the RMSEA, which shows values higher than 0.08. Measurement invariance by sex and age group was present. The majority of university students in E-learning showed use of the bibliographic manager Mendeley (52.13%), low ability to use information databases such as Scopus (22.24%) or Web of Science (17.26%), and the least skilled research skills were in formulating the problem, objectives, and hypotheses (51.63%) and carrying out data analysis and processing using statistical techniques (49.37%).
Conclusions: The conclusions of the study were that the 8-item research skills instrument presents acceptable psychometric indicators in Peruvian university students in thesis courses. Likewise, a scarce use of global databases, the approach to the research topic, and carrying out its statistical processing.

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1. Introduction

The main goal of undergraduate research is to help students learn and develop research skills as they advance in their academic careers. When a student begins a professional career, the development process begins and continues until the student can conduct independent research under the supervision of a mentor [1]. University students must develop research skills to improve their critical thinking and problem-solving abilities and generate new knowledge. Furthermore, learning to conduct research produces skills that are reflected in their professional field [2,3]. While some students get involved in research early on and feel connected to it, others see it as a distant phenomenon [4]. While they recognize the value of research practice in their studies, they require a realistic understanding of the research process [5]. In this regard, it is critical to promote and develop research capacities within the higher education curriculum [6]. Some academic institutions or programs may integrate research skills throughout the curriculum, resulting in a well-planned research strategy [7].

There is little evidence to support the use of instruments to assess research skills and psychometrics [7–9]. A systematic review found seven studies that evaluated research capabilities, three of which performed and reported on the psychometric validation of these instruments [10]. A study on philosophy students was conducted in Serbia, and the results show that students have difficulty using digital and virtual libraries [11]. A study on medical students in Sri Lanka discovered that 64% generated research ideas and 78% had difficulty conducting a literature review [8]. According to a Spanish study, the students evaluated had a lower ability to perform bibliographic searches and citations [12]. Two Mexican studies discovered that the application of research capabilities has increased by 13.49% [13,14]. According to three Peruvian studies, the level of research competence development among students is intermediate, regular, and insufficient [15–17]. It should be noted that none of the studies used psychometric or statistical tests to validate their instruments. The reality of research skills appears to be caused by a lack of knowledge and research abilities in university education, given that research skills are still not included in the curriculum in the majority of places [18]. Furthermore, failure to use validated instruments may result in biased and overestimated results [19].

The Peruvian Ministry of Education's initiative to close educational gaps in analytical skills had a significant impact on high school students. However, factors such as the student's socioeconomic status, a lack of school supplies, and insufficient strategy application, among others, have mediated the effect on the expected results [20,21]. In this regard, the National Superintendence of Higher Education (SUNEDU) is the agency responsible for regulating, supervising, and promoting the development of these research skills by Peruvian universities through appropriate curricular design [22]. Currently, all Peruvian universities are actively involved in the development and training of research skills in their students through research projects, activities, and courses [22]. However, the capacities developed during university education must still be measured, and instruments with appropriate and valid indicators are required to do so.

There is a dearth of adequately validated and comprehensive instrument to assess research skills in Spanish-speaking higher education. In some cases, the studies reviewed do not specify how their instruments were validated [23]; in others, psychometric validation was performed but only exploratory factor analysis was performed [24]. The exploratory factor analysis is an a priori evaluation that aims to identify the number of factors that explain the items; however, it is not conclusive, so confirmatory factor analysis is used to verify the adequacy of the instrument's validity [25]. The Vera-Rivero (2021) [26] study generated a Spanish instrument that, despite its importance and conciseness for use with university students, lacks psychometric validity. The main contribution of the current work to the international literature is statistical validity, as it aims to adapt and validate a scale that can be used to measure research skills in formative research, and to demonstrate its characteristics in an E-learning teaching environment. Based on the above, the main objective of this study was to evaluate the psychometric properties of the research skills instrument. In addition, our objective was to evaluate the degree of development of research skills with respect to knowledge of the research process, the use of databases, and bibliographic management in Peruvian undergraduate university students enrolled in the thesis course.

2. Materials and methods

2.1. Design and study area

We conducted a psychometric and descriptive study using data from undergraduate students at a private Peruvian university who were contacted between July and December 2020. The study included university students from five campuses in Peru's urban regions: Piura, La Libertad, Lima, Ayacucho, and Ucayali. These cities are spread throughout Peru; the first three are located within the natural area of the coast; the fourth region is in the highlands, and the last is in the jungle; all present differences in socio-cultural traits [27]. During the study period, the number of students enrolled in thesis courses to obtain a bachelor's degree within the regions was 18,165, distributed in Piura (n = 4339), La Libertad (n = 889), Lima (n = 2646), Ayacucho (n = 3105) and Ucayali (n = 1460).

2.2. Sample size

A total of 1598 Peruvian university students were surveyed, included through non-probabilistic convenience sampling, and enrolled in e-learning research thesis courses. It should be noted that the pandemic was at its peak from July to December 2020, so in order to avoid jeopardizing university students' progress, all teaching was done online. In general, this sample was representative in terms of sex and natural area, having as a reference a nationwide base [28] (Appendix A). The exclusion criteria were: not being enrolled at the time of the application of the instrument in any of the thesis courses; being under 18 years of age; not accepting the

informed consent; and not having completed more than 50% of the questionnaire.

2.3. Study variables and instruments

Research skills: In this study, we collected information from university students using the research skills self-perception instrument developed and validated by experts in the study by Vera-Rivero et al. in Cuba [26]. The original scale consisted of 9 items with 3 response categories (1: inadequate, 2: medium-adequate, and 3: adequate) structured according to the knowledge and skills of the different sections that make up a thesis, use of bibliographic managers, and exposition of the study carried out.

The authors reviewed the research skills self-perception instrument and had it theoretically validated by experts, keeping in mind that the goal is to identify knowledge and skills for the development of the undergraduate thesis, with the exception of item 9 9 on research exposition skills. We consider the final version of eight items (Appendix B), which considers the following: the use of catalogs, the formulation of a scientific problem; the selection of the population and sample; the development and application o methods; the analysis and processing of information using statistical techniques; the interpretation and discussion of results; the elaboration of conclusions and recommendations; and the writing of the final thesis report. The most recent version of the instrument provided scores ranging from 8 to 24 points.

Covariates: We included sociodemographic variables: region of residence (Piura, La Libertad, Lima, Ayacucho, and Ucayali), sex (male and female), and age group (17–22, 23–30, and 31 and over). In addition, academic variables such as academic year (third, fourth, and fifth year), information databases (Scopus, Web of Science, Pubmed, and Scientific Electronic Library Online (SciELO)), and bibliographic information managers (Endnote, Mendeley, other, and I do not use) were included.

2.4. Procedure

The authorities in charge of the private university in Peru were contacted to request support in the application of the questionnaire to their students, and they were informed of the objective of the study and were able to obtain the list of students enrolled in the data collection period in the selected regions within the E-learning thesis courses. Subsequently, the voluntary participation of students was promoted via email and WhatsApp. Students who were interested in participating were given access to the instrument hosted online within the Google Form. The instrument first had information explaining the importance of the study, voluntary and anonymous participation and, finally, how to complete the questionnaire. Students who have decided to participate accepted the informed consent and started filling in the questionnaire.

2.5. Statistical analysis

Psychometric analysis: First, exploratory factor analysis was performed using the weighted least squares robust mean and variance adjusted weighted least squares (WLSMV) estimator, using polychoric matrices and oblique rotation (“quatirmin”) to obtain factor loadings that aim to assess how items correlate within the one-dimensional model by total sample and regions. In addition, parallel analysis and Kaiser-Meyer-Olkin (KMO) were performed to determine if there were enough participants to evaluate the one-factor model, with an adequate KMO value being greater than 0.08 [29].

A two-stage confirmatory factor analysis was then carried out in response to models in which different indicators were used to obtain their fit. The indicators taken into account were the comparative fit index (CFI) and the Tucker-Lewis index (TLI), which are adequate when they are greater than or equal to 0.90 [30]. In addition, the normalized root mean square residual index (SRMR) and the root mean square error of approximation (RMSEA) are adequate when they are less than or equal to 0.08 [30]. The structure of the first model was based on the items of the original instrument, excluding item 9. For the second model, correlated errors were added because the RMSEA goodness-of-fit indicator showed its value to be greater than 0.08 and identified the existence of a strong correlation between items [31].

Thirdly, the reliability of the instrument was obtained through the Cronbach’s Alpha, ordinal Alpha, and Omega indicators, being adequate with values greater than 0.80 [32]. Finally, measurement invariance was performed to assess whether comparisons between sexes and age groups are possible, using a series of nested models (configural model; metric invariance model; and scalar invariance model). To evaluate these nested models, the variation (Δ) of goodness-of-fit indicators (CFI and RMSEA) of the restricted models concerning the configural model was taken into account. There is evidence of group invariance when the variation of CFI is less than or equal to 0.010 and RMSEA is less than or equal to 0.015 [33,34]. The Rstudio software was used for psychometric property analyses, along with the packages “lavaan”, “semTools”, and “semPlot” (Rstudio®, Boston, MA, USA).

Descriptive analysis: In order to identify the characteristics of the research skills instrument, information databases, and bibliographic managers of university students studying undergraduate research subjects, frequencies and percentages were shown. With respect to the level of research skills and age groups, they were generated from regional cut-off points using percentile rankings. Analyses were performed in Stata v16.0 statistical software (StataCorp, TX, USA).

2.6. Ethical considerations

The students who agreed to participate voluntarily gave their informed consent. The Helsinki Declaration was taken into account for the present study, and the protocol was approved by the ethics committee of the Los Angeles Catholic University of Chimbote, as issued in report N° 118-2020-CIEI-VI-ULADECH-CATOLICA.

3. Results

3.1. Participants

There were 1598 students from a private university and most were female (70.53%, 95%CI: 68.24%–72.71%), mostly single (67.80%, 95%CI: 65.50%–70.08%) and aged 23–30 years (33.54%, 95%CI: 31.27%–35.90%).

3.2. Exploratory factor analysis

For the exploratory factor analysis of research skills for academic degrees, we used the least squares means and variance adjusted variance estimator (WLSMV), the polychoric matrix, and the oblique rotation method (quatirmin), since it was a better fit for ordinal categorical data [35]. This analysis showed that the factor loadings for the one-factor model are adequate ($\lambda \geq 0.49$), both at the total sample level and by region (Table 1). In addition, parallel analysis was previously obtained to identify the adequate number of dimensions [36], indicating that the research skills items should be grouped in a single factor model, and finally, the Kaiser-Meyer-Olkin (KMO) estimator was obtained, where values greater than 0.90 refer to the existence of adequate sample size for the psychometric analyses [37], confirming that the present sample size is adequate for the present analysis (Appendix C).

3.3. Confirmatory factor analysis

We also evaluated the one-factor model for the confirmatory analysis using the WLSMV estimator and the polychoric matrices that were also used in the EFA, yielding a variety of indicators that together show us a comprehensive interpretation of the factorial structure's complexity. We discovered the CFI, TLI, and SRMR for an 8-item questionnaire on university students' research skills to be adequate goodness-of-fit indicators. The original 8-item model, on the other hand, was found to have insufficient RMSEA values (>0.08). (Appendix D). As a result, correlation errors were calculated for each pair of items, and correlation errors between items 7 and 8 were found to be extremely high (Appendix E). As a result, the analysis was repeated, this time taking into account the correlation between the errors of these two items. In comparison to the first model, the goodness-of-fit indicators improved, with adequate indicators for both the total sample and the regions (CFI >0.90, TLI >0.90, and SRMR = 0.08). Fig. 1 depicts the factor loadings of the model with correlated errors for the entire sample. Finally, Cronbach's alpha, ordinal alpha, and omega reliability indicators demonstrated optimal levels with values greater than 0.89 (Table 2).

3.4. Measurement invariance

The confirmatory factor analysis model was used to determine the invariance of the investigative skills instrument according to gender and age groups, that is, to determine whether the different groups had an equivalent understanding of the evaluated construct; if the groups were equivalent to each other, they are defined as invariant, and thus comparisons can be made between them. Males (n = 1127) and females (n = 471) achieved measurement invariance, allowing comparisons between both groups due to their equal conformation in the construct (CFI 0.010; RMSEA 0.015). Furthermore, measurement invariance was achieved across three age groups (12–22 years = 574; 23–30 years = 536; and 30 years or older = 488), allowing group comparisons (CFI 0.01; RMSEA 0.015) (Table 3).

Table 1
Item descriptions and factor analysis modelling of the research skills instrument.

Items for knowledge and skills	Factor loadings (λ)							
	M	SD	Overall (n = 1598)	Piura (n = 499)	La Libertad (n = 225)	Lima (n = 351)	Ayacucho (n = 342)	Ucayali (n = 181)
1: Use of catalogues, descriptor books and bibliographic records.	2.432	0.576	0.675	0.721	0.562	0.675	0.600	0.68
2: Relation to the formulation of a scientific problem, research objectives, and research hypotheses.	2.419	0.555	0.759	0.726	0.824	0.759	0.747	0.677
3: Selection of the population, the sample, and the type of sampling to be used.	2.476	0.571	0.744	0.696	0.816	0.744	0.731	0.637
4: Selection, development, and application of methods, techniques, and instruments.	2.487	0.556	0.796	0.755	0.826	0.796	0.749	0.816
5: Analysis and processing of information through different statistical techniques.	2.409	0.583	0.814	0.821	0.844	0.814	0.760	0.829
6: Interpretation and discussion of results presented in tables and graphs.	2.431	0.576	0.792	0.743	0.854	0.792	0.789	0.699
7: Drawing up conclusions and recommendations.	2.533	0.546	0.786	0.736	0.764	0.786	0.819	0.744
8: Writing final research reports.	2.486	0.556	0.777	0.776	0.867	0.777	0.649	0.760

Abbreviations: M, mean; SD, standard deviation; λ, standardized factor loadings.
Note: The scale of the items ranges from 1 to 3 points.

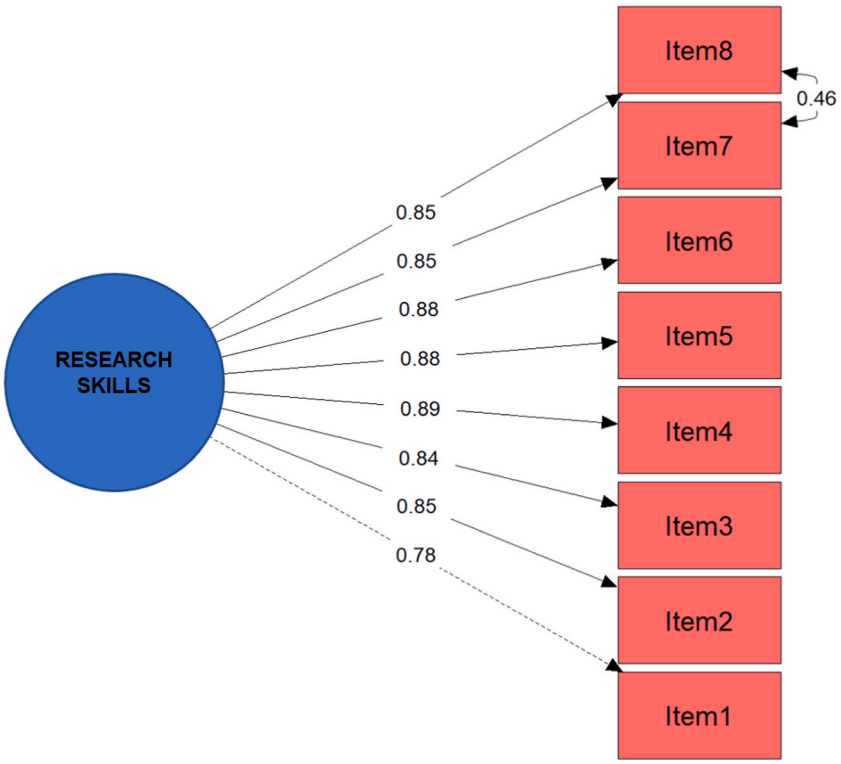

Fig. 1. Confirmatory Factor Analysis model with correlated errors-standardized factor loadings for all participants (n = 1598). Note: CI= Research Skills.

Table 2
Confirmatory factor analysis with correlated errors - goodness-of-fit and reliability indices.

	Overall (n = 1598)	Piura (n = 499)	La Libertad (n = 225)	Lima (n = 351)	Ayacucho (n = 342)	Ucayali (n = 181)
X^2	261.927	144.899	79.804	61.653	44.365	55.588
df	19	19	19	19	19	19
CFI	0.991	0.983	0.993	0.994	0.996	0.985
TLI	0.987	0.975	0.989	0.991	0.994	0.978
RMSEA	0.089 [0.080–0.099]	0.115 [0.098–0.133]	0.120 [0.093–0.147]	0.080 [0.058–0.103]	0.063 [0.039–0.087]	0.103 [0.072–0.136]
SRMR	0.030	0.049	0.042	0.030	0.026	0.053
α	0.915	0.904	0.941	0.921	0.907	0.896
$\alpha_{ordinal}$	0.956	0.949	0.972	0.960	0.951	0.945
Ω	0.903	0.894	0.930	0.912	0.898	0.883

Abbreviations: χ2, Chi square; df, degrees of freedom; RMSEA, root mean square error of approximation; CI, confidence interval; SRMR, Standardized root mean square residual; CFI, comparative fit index; TLI, Tucker–Lewis index; α, Cronbach's Alpha; $\alpha_{ordinal}$, Ordinal Alpha; ω, Omega Index.

Table 3
Measurement invariance test according to sex (male vs female) and age group (17–22, 23–30, 31 and older).

Model	X^2	Df	CFI	TLI	RMSEA	SRMR	ΔCFI	ΔRMSEA
Measurement according to sex								
1.-Configural invariance	270.278	38	0.992	0.988	0.088	0.030	–	–
3.- Metrict invariance	287.405	45	0.991	0.989	0.082	0.030	0.001	0.006
4.- Scalar invariance	298.598	52	0.991	0.991	0.077	0.030	0.001	0.011
Measurement according to age groups								
1.-Configural invariance	323.541	57	0.991	0.987	0.094	0.035	–	–
3.- Metrict invariance	319.756	71	0.992	0.990	0.081	0.035	0.001	−0.013
4.- Scalar invariance	334.822	85	0.991	0.992	0.074	0.035	0.000	−0.007

Abbreviations: χ2, Chi square; df, degrees of freedom; RMSEA, root mean square error of approximation; SRMR, Standardized root mean square residual; CFI, comparative fit index; TLI, Tucker–Lewis index.

3.5. Characterization of the research capacities, information databases and bibliographic managers

Peruvian university students, within the E-learning thesis courses, presented a medium level of self-perception of research skills (35.04%, 95%CI: 32.74%–37.41%). Within the characteristics of research skills, they presented medium-adequate levels in the usability of bibliographic material (49.12%, 95%CI: 46.68%–51.58%), the formulation of the scientific problem, objectives and hypotheses (51.63%, 95%CI: 49.17%–54.07%), data analysis and processing using statistical techniques (49.37%, 95%CI: 46.92%–51.83%) and interpretation and discussion of results (48.25%, 95%CI: 45.80%–50.70%). On the other hand, university students demonstrated an adequate level in the research skills of drawing conclusions and recommendations (55.82%, 95% CI: 53.37%–58.24%) and writing final reports (51.56%, 95% CI: 49.11%–54.01%) (Table 4).

Regarding the use of information databases by Peruvian university students for their theses in the context of E-learning, 81.5% use SciELO, with female (88.85%) and young people between 17 and 22 years old (87.34%) being the most frequent users. The use of Web of Science and Scopus databases was reported by 17.26% and 22.24% of respondents, respectively. Finally, 52.13% of the participants use the bibliographic reference manager Mendeley, with females (54.48%) and university students aged 17–22 (53.17%) using it the most (Table 5).

4. Discussion

We evaluated the psychometric properties (validity and reliability) of the research skills instrument in E-Learning university students in Peru. The research skills instrument as a one-factor model showed adequate goodness-of-fit indices with optimal levels of reliability. Likewise, the measurement invariance was consistently good, which allowed comparisons between sexes and age groups. A regular level of investigative skills was found in university students, and a lower perception of skill in statistical analysis and discussion of results. The bibliographic manager Mendeley was the most used, while the Web of Science and Scopus databases were used infrequently.

4.1. Psychometric properties

According to our findings, the research skills instrument fits a one-factor model and can be assessed with fewer items. The RMSEA goodness-of-fit index improved in the model with correlated errors, but it is still insufficient (<0.08) for the total sample and regions. The similar wording and close proximity of these items on the scale could explain this situation [38]. The items in the research skills instrument are conceptually similar to those proposed in other recently published psychometric scales. In fact, in China, the Research Competencies for Nursing Students scale (NCS–N) [39] has a single factor with appropriate adjustment indices (RMSEA = 0.076; CFI = 0.978; SRMR = 0.021) that includes the areas and sections considered in our instrument (designs, methods, and statistical analysis, formulation of the research problem and access to databases). . However, the RCS-N was developed in a smaller sample of students (n = 146), and logically in a population culturally different from the Peruvian population. Another study found an internal consiste|ncy with an alpha of 0.82 (adequate) in the Research Perceptions scale in the research skills domain, which consisted of seven items for medical students in the United States, but it did not report other psychometric values such as goodness-of-fit indices [40]. Other multidimensional scales, such as the Nursing Research Questionnaire, propose evaluating factors such as research knowledge, attitudes toward research, use of material resources, and use of research in practice. However, this instrument reports oscillating values in its instrument reliability of 0.25 and 0.93, as well as the absence of other values [39]. We believe our instrument assesses the most relevant indicators for undergraduate students' research skills. In addition to adequate adjustment and reliability indexes, our scale was tested on a larger population of Peruvian students from various locations and professions.

4.2. Reliability

Our findings show that the internal consistency and reliability coefficients for the research skills instrument are optimal. This

Table 4
Characterization of research skills.

Items for knowledge and skills	Inadequate	Moderately Adequate	Adequate
1: Use of catalogues, descriptor books and bibliographic records.	61 (3.82%)	785 (49.12%)	752 (47.06%)
2: Formulation of a scientific problem, research objectives, and research hypotheses.	52 (3.25%)	825 (51.63%)	721 (45.12%)
3: Selection of the population, the sample, and the type of sampling to be used.	61 (3.82%)	716 (44.81%)	821 (51.38%)
4: Selection, development, and application of methods, techniques, and instruments.	48 (3%)	724 (45.31%)	826 (51.69%)
5: Analysis and processing of information through different statistical techniques.	78 (4.88%)	789 (49.37%)	731 (45.74%)
6: Interpretation and discussion of results presented in tables and graphs.	69 (4.32%)	771 (48.25%)	758 (47.43%)
7: Drawing up conclusions and recommendations.	39 (2.44%)	667 (41.74%)	892 (55.82%)
8: Writing final research reports.	47 (2.94%)	727 (45.49%)	824 (51.56%)
Research skills:			
Low (8–17 points)	547 (34.23%)		
Medium (18–22 points)	560 (35.04%)		
High (23–24 points)	491 (30.73%)		

Table 5
Characterization of the use of information databases and bibliographic reference managers according to total sample, sex, and age group.

	Overall	Sex		Age group		
		Female	Male	17–22	23–30	31 to more
Information databases						
Scopus	125 (22.24%)	86 (21.18%)	39 (25.00%)	51 (21.52%)	42 (24.14%)	32 (21.19%)
Web of Science	97 (17.26%)	61 (15.02%)	36 (23.08%)	30 (12.66%)	42 (24.14%)	25 (16.56%)
Pubmed	29 (5.16%)	19 (4.68%)	10 (6.41%)	9 (3.80%)	14 (8.05%)	6 (3.97%)
Scielo	460 (81.85%)	338 (83.25%)	122 (78.21%)	207 (87.34%)	133 (76.44%)	120 (79.47%)
Bibliographic reference managers						
Endnote	11 (0.69%)	9 (0.8%)	2 (0.42%)	4 (0.70%)	4 (0.75%)	3 (0.61%)
Mendeley	833 (52.13%)	614 (54.48%)	219 (46.5%)	318 (55.4%)	285 (53.17%)	230 (47.13%)
Others	475 (29.72%)	321 (28.48%)	154 (32.7%)	166 (28.92%)	155 (28.92%)	154 (31.56%)
Does not use	279 (17.46%)	183 (16.24%)	96 (20.38%)	86 (14.98%)	92 (17.16%)	101 (20.7%)

finding is consistent with the Chinese Research Competencies Scale for Nursing Students, which reported a one-factor structure with 24 items and an alpha of 0.98 [38], and the Research Competencies Assessment Instrument for Nurses, which had 19 items divided into three dimensions (understanding, skills, and application in the research process) [41]. Furthermore, the Colombian scale to assess formative research skills in students reported a similar finding with an alpha of 0.82; however, this scale is very extensive with 42 items, and it is not specified which population group it is aimed at in the applied study [42]. Despite having fewer items, our scale does not lose information and has a high level of internal consistency. The minimum item count (8 items) and the high-reliability measurement indices distinguish our scale from others.

4.3. Measurement invariance

Our findings support the notion that the research skills instrument has convincing measurement invariance across age groups and sex, allowing for comparisons across these groups. Although some studies have found no differences in research skills between sex, they have found differences in age groups. However, it is unclear whether the differences in these studies are due to biases in the interpretation of the instrument's items or to the research experience that years of professional practice can provide. In this regard, no studies have been conducted to date that has evaluated the measurement of measurement invariance in instruments of research capabilities. Scales are frequently used to evaluate and compare groups, even when there is insufficient evidence to perform these analyses [43]. Despite this, several studies use the Research Competence Scale (RCS) and assume that it functions identically regardless of the demographic diversity of the different groups and without evidence of the instrument's invariant functioning [44,45]. The evidence of invariance across age groups indicates that the items on our scale correctly assess research skills for young people up to and over the age of 22, which corresponds to the age at which students in Peru graduate and receive university training to develop these skills [22].

4.4. Characterization of research skills, databases and bibliographic managers

The perception of research skills in university students was low in the statistical analysis and discussion of results sections. University students from other parts of the world have reported limitations in these areas [46,47]. These findings could be the result of a number of factors, including teachers' use of ineffective methods of teaching statistics, particularly in non-mathematics-oriented careers [48], and students who, if they do not achieve adequate learning, will adopt a negative attitude toward this type of analysis [49,50]. Similarly, Peru's low proficiency in analytical and mathematical skills has been observed in several foreign evaluations since the school stage [20], which is related to the perception of statistical difficulties during the university stage [21]. The Peruvian Ministry of Education (MINEDU) has implemented programs to close these gaps, such as a full school day with pedagogical content based on student feedback; however, the impact of these programs would be hampered by other factors such as the student's socioeconomic level, a lack of school supplies, insufficient application of strategies, and so on.

For information searches, however, the SciELO database was more popular than SCOPUS and the Web of Science (WoS). In fact, previous research has shown that students use SciELO as their first source of information search. The issue is that students overestimate their ability to identify and select quality scientific information by favoring SciELO over databases such as Scopus or WoS [51]. SciELO has some limitations, such as the variety of topics it covers and the regional scope of its publications, given that it is made up of journals and publications from Ibero-American countries. Scopus and WoS, on the other hand, overcome these limitations by providing students with access to thousands of scientific journals with peer-reviewed articles from around the world. They also include a wide range of disciplines with various search options (year of publication, journal name, country, full access, and so on) and simple operators for a more precise search. The National Council for Science, Technology, and Technological Innovation (CONCYTEC) in Peru provides free access to databases such as Scopus and SUNEDU, emphasizing the importance of Scopus and WoS publications as a fundamental product of research in Peruvian universities. As a result, developing these abilities is critical because relying on knowledge based on scientific evidence is essential for carrying out academic research work such as theses and scientific articles.

4.5. Implications in higher education

Research skills for students require teachers to have research knowledge. The financing of research projects for teachers that involves the inclusion of students represents a resource to promote research training from students from the first years of their studies [52]. Collaborative research groups made up of research professors and mentors represent another opportunity for undergraduate students to progressively develop their research skills by fulfilling various assigned tasks such as information search, methodology, basic analysis, data collection and manuscript writing [53].

The National Superintendence of Higher Education (SUNEDU) is the agency in charge of regulating, supervising, and promoting the development of these skills by Peruvian universities through appropriate curricular design [22]. All universities in Peru are currently taking an active interest in the development and training of research skills in their students through research projects, activities, and courses [22]. It is necessary to have instruments with appropriate indicators to measure the capacities developed during university education.

Research is a challenge that education must take on to promote the development of creative, critical and autonomous people, capable of participating in the construction and improvement of society. To that end, the university's research must prioritize the formation of alliances with national and international institutions that serve as models for their development in research and innovation, in order to benefit from their experience in management as well as in the development of strategies for education, training, and strengthening of the capacities of teachers, researchers in training, and students. In addition, the curricula of the academic programs must be improved to enhance the subjects related to research training in undergraduate students.

4.6. Strengths and limitations

This is the first study in Peru to apply the research skills scale to university students in northern, central, and southern Peru with a large sample (n = 1598). Furthermore, it is the first study worldwide to include a factorial invariance analysis in an instrument that assesses research skills in university students. The presence of selection bias was presumed since participation was voluntary and the presence of previous symptoms was not taken into account. First, it is important to mention that the RMSEA value in the total sample reported a value of >0.08. Second, the research skills instrument was used to assess college students' self-perceptions of their research abilities. Because of Peruvian college students' obvious weaknesses in scientific research, the answers obtained are likely to be biased and overestimate their research skills. However, many institutions have taken the initiative to create a matrix of gradualness in the university period to strengthen research skills. Finally, we think the proposed study provided a framework for future research on college students' research skills [54,55]. Third, the use of non-probability convenience sampling could generate selection bias, because the participants who respond more frequently to the questionnaire may be those who are more interested in topics related to the research. Finally, our results focus on the Peruvian context, and our sampling is not generalizable. Therefore, our findings cannot be extrapolated to other countries in the region. However, we consider that the reality of higher education in research in Peru does not differ much from other low and middle-income countries, which are characterized by low investment in science and technology [56].

5. Conclusions

The one-factor research skills scale is valid and reliable for Peruvian university students of both sexes and age-groups in an E-Learning environment. Therefore, the authors recommend the use of the instrument for future research and evaluation of research skills in the Peruvian context.

Also, the university students reported adequate use of bibliographic managers. However, they perceived a lower ability to focus on their research topic (study problem, objectives) and apply statistical techniques for data processing. In addition, there was limited use of global databases for literature searches in young male and female college students. Our study suggests the need to strengthen research skills in Peruvian university students.

Future research should carry out studies to accumulate evidence of the psychometric properties found in this scale. The measurement invariance of the scale is due to other different groups. In addition, study programs can be developed for the formation of research skills that can be evaluated with this instrument.

Author contribution statement

M. Ipanaqué-Zapata, J. Figueroa-Quiñones, J. Bazalar-Palacios, W. Arhuis-Inca, M. Quiñones-Negrete and D. Villarreal-Zegarra: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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Data availability statement

Data will be made available on request.

Declaration of interest's statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2023.e13770.

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