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Research Perceived Competency Scale: A New Psychometric Adaptation for University Students' Research Learning

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Abstract: This research aimed to adapt and validate a measuring scale of perceived research competencies among undergraduate students. Perceived research competencies of undergraduate learning can be measured with a new scale adapted from self-determination theory. We assessed the validity of this new measure applied to 307 participating undergraduates from Lima (Peru). The instrument's survey items in the perceived competencies scale were first translated from English to Spanish and then adapted to focus on participation in research activities. We obtained evidence for (a) content validity (through item analysis), (b) internal structure with Mokken Scaling Analysis and structural equation modeling to examine the item–construct relationship, differential item functioning, and reliability, and (c) association with external variables. The items were found to function one-dimensionally, with strong item–construct relationships and no differential functioning (academic semester and general self-esteem groups). Theoretically consistent associations were found between study satisfaction and anxiety symptoms (controlling for gender, semester, and social support). We also discussed the theoretical implications and practices of this newly adapted measurement instrument.

Keywords: perceived competencies; research learning; validity; self-determination; differential item functioning; higher education; educational innovation; professional education

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1. Introduction

Learning and developing research skills implies approaching scientific knowledge and managing research methodology through university studies [1]. Although participating in research is rare in undergraduate student activities learning [2], academic environments provide the best opportunities to approach reading and writing strategies, codes and meanings associated with research, and elements related to positive changes in self-efficacy, research interest, and perceived competency to complete research [3]. Various methodologies have been proposed for research-based learning, oriented to developing students' skills in research. One is research-based learning (RBL), a didactic strategy that connects teaching with research, allowing students to be active researchers, develop competencies, and prepare to be lifelong inquirers [4,5]. Among the most important advantages are stimulated reading and critical thinking through self-directed learning, problem-solving, and greater interest and curiosity for learning.

The motivation to become involved in research activities seems to be associated with the educational institution's culture, teaching strategies, or psychosocial aspects [6–9].

Achieving good research skills and knowledge requires an approach that facilitates understanding how the environment and motivation interact. In this sense, self-determination theory postulates that motivated behavior varies depending on the level of autonomy or control a person has regarding their tasks [10]. Unlike contextually controlled behaviors, which appear due to interpersonal pressures or demands, autonomous behaviors are intrinsically motivated. These arise out of self-interest and are accompanied by spontaneous thoughts and feelings [10,11]. When students enter a lecture with high autonomous motivation, they report more positive experiences, greater perceived competency and interest, and less anxiety at the end of the class [10]. Research on self-determination has found that approaches that influence autonomy yield better educational results than controlled approaches. Considering that the satisfaction of basic psychological needs of students, such as competency, autonomy, and affinity, promotes greater participation, better learning processes, and the well-being of students, more practical applications of self-determination theory in education are needed [12].

Competency, in general, refers to the cognitive, motivational, and social conditions necessary for successful learning [13]. Competencies involving effective interaction with others, teamwork, self-efficacy, and decision-making comprise some valuable soft learning skills [14]. Acquired in the learning process, these stabilize over time; they are precursors of possible behavioral actions. Evidence indicates that the focused perception of these competencies also influences the intention to engage in related activities [15]. Therefore, student perception of their competency to carry out research activities is complex and is associated with several possible components, such as the practical ability to complete research with minimal help and the knowledge of what is expected of them during evaluation processes [6]. In an applied context, the perception of high levels of competency and trust in developing research projects is a precursor to the effort invested in the quality of the project [6].

The concept of competency in skill development is related to self-efficacy, which is the belief that the student has that they are capable of performing a task or achieving an objective [16]. There is already an established relationship between academic self-efficacy and educational results, which, together with autonomy and competency, maintain intrinsic motivation in learning [17,18]. Moreover, to improve self-efficacy and competency, students require opportunities to experience academic achievement in various tasks since the experience of success enhances beliefs of self-efficacy [17]. Moreover, perceived competency can subsume the student's sense of self-confidence, developed from accumulated experiences of achievement and effective coping with problems, and their monitoring of these processes [19,20].

In the self-determination theory, academic self-efficacy and constructive feedback help students develop research skills and the confidence to use them. Simultaneously, they allow the development of feelings of well-being [12], given that in the students' perception, competency, autonomy, and affinity are fundamental elements for this task, promoting their independence in self-evaluation and improvement. The development of academic skills, particularly those required for research, is also linked to interpersonal goals that facilitate the career path [21]. These domains may be involved in the perception of competencies to execute them. Moreover, self-efficacy beliefs partially mediate the effects of research skills [22]. For example, we can mention the course-based undergraduate research experiences (CUREs), learning experiences where students address a research problem with an unknown solution. These large-scale, original, hands-on research practices are primarily used in laboratory courses [23]. They can be offered as early as the first years of the student's major [24,25], providing advantages such as enhanced confidence and skill development in doing research [26,27], significantly increased retention among science, technology, engineering, and mathematics (STEM) majors [28,29], and more inclusion in the sciences of underrepresented populations [30].

Regarding the approaches to measure research competency, the predominant method has been self-report measures. Due to the possible complexity of the construct, instrumental

studies have pointed to the specific content of low factorial order, possibly sensitive to the interaction between individual variability and the demands of the educational environment in the USA [7], Germany [9], and Malaysia [31]. Although the constructs evaluated in instruments have a relative convergence in identifying the structure of research competencies, the psychometric methodology used is highly heterogeneous with sample size (between these studies, the sample size ratio was 3.8). On the other hand, the indicated evaluation instruments are oriented to study research competencies from a cognitive and pedagogical approach, formulated to identify academic strengths and weaknesses in the teaching-learning process. However, motivational aspects, such as perceived competency or interest in research, were not considered and represented a significant metric limitation.

Perceived self-competency is installed in self-determination theory as one of the three crucial psychological needs for a person to maintain their behavior towards adaptive goals. Consequently, an instrument was developed in educational and health research and intervention [32,33] to quantify an essential mediating component within the self-determination model: Perceived Competency Scale (PCS). Items from the Perceived Competency Scale (PCS) were developed for a particular behavioral domain. The high psychometric consistency usually found in these domains indicates that sampled behaviors are strongly correlated but with content that is not necessarily redundant. According to this, applying the PCS in specific thematic contexts requires relevant content modifications. For example, the content has been modified for randomized interventions in dental health [34], glucose control with diabetic patients [35–38], weight loss strategies [39], and tobacco dependence [40]. In general, the empirical evidence of the mediating role of perceived competency was corroborated in understanding the effects of interventions based on the model of self-determination.

The objective of this study was to evaluate the psychometric properties of the PCS applied to research activities during university education through item validity, analysis of their internal structure, and their convergent association with other constructs. This objective is fundamental to (a) establish the first psychometric evidence for the interpretation and use of its scores and (b) because, to date, no adaptation of the PCS has been made to assess self-observed competency to conduct research activities, and the ways in which adapting its content would work in this regard is still unknown. As part of the assessment of the internal structure, this objective also focuses on the assessment of item similarity and their relationship to their construct (i.e., tau-equivalence) and item-level reliability. Content adaptations of the PCS have essentially occurred in health interventions, which can usually be identified as a field of application and research different from it. An additional motivation that reinforces the objective of this study is that in Latin American countries, scientific research activity needs to be strengthened in the classroom. There is a growing interest in its inclusion, as shown in the cases of Chile [41], Mexico [4,42], and Peru [43,44]. On the other hand, assessment of perceived research competency can be incorporated into initiatives to increase research participation and monitor the change in undergraduate [45,46] and graduate [47,48] students' skills in academic courses.

The application of the PCS in other contexts of behavioral functioning, such as the subject's participation in scientific research, can be a way to associate motivation and maintenance in research activities with efficiency and scientific productivity. In higher education, the perceived research competency can be conceived within a general perception of competency related to learning because research skills usually develop in university studies. The university's contextual activities and opportunities affect the perceptions about conducting it effectively. Examples include individual or group work on research projects and presentation of results or projects in intramural or external events, as highlighted in the literature (e.g., [21,49]). Consequently, educational strategies can arise from evaluating the competencies to complete research. According to the above, the hypothesis is raised that perceived research competency has a linear, positive effect on satisfaction with studies, the latter being understood as the perception of satisfaction with performance, the set of activities and results of the study, and the way of approaching the studies [50].

Due to the corroborated covariation of social support, persistent emotional reactions (e.g., anxiety symptoms), and self-esteem on perceived personal competencies and academic performance [51–55], we explored its effects with the construct developed in this study (i.e., perceived research competencies). The aim was to accumulate evidence of the construct's conceptual network and evaluate if it was relevant for student intervention, monitoring, and promotion strategies.

2. Materials and Methods

2.1. Participants

The population for this study comprised Peruvian students in private universities in Metropolitan Lima (Peru), predominantly of medium socioeconomic status. The study used non-probabilistic sampling, and we decided the selection of the participating university by the opportunity of access and the exploratory initiative of the study. Participants who did not sign the informed consent form or enrolled in the first five semesters of their academic program were excluded from the sample because research methodology courses and intramural or extramural experiences occur around the 6th semester in Peruvian universities.

The effective sample comprised 307 psychology undergraduate students with a mean age of 23.08 (S.D. = 3.8) and between 19 and 44 years of age. The sample was predominantly female (n = 222, 72.3%); a little more than a quarter were men (n = 84, 27.4%), and a single participant chose not to disclose their gender (n = 1, 0.3%). The males were older (t = 2.29, df = 301, $p < 0.05$, d = 0.296). Moreover, 155 participants (50.5%) were employed. The student's current semester varied between the 6th (n = 29, 9.7%), 7th (n = 74, 24.1%), 8th (n = 44, 14.3%), 9th (n = 84, 27.4%), 10th (n = 63, 20.5%), and 11th (n = 7, 2.3%). Only 6 participants (2%) did not report their semester. A total of 267 Participants were predominantly born in Lima (87%), 280 were single (91.2%), while the rest were married or cohabiting (n = 16, 5.2%). Eight participants (2.6%) did not provide information in this regard.

2.2. Instruments

Research Perceived Competencies Scale (RPCS). This measuring instrument assessed student perceptions of competency for research activities. It was composed of four items derived from the generic content model proposed by Williams and Deci [32]: confidence perception, ability, goal achievement, and overcoming challenges. The response format was scaled with seven options, from "Not at all true" to "Very true", and grouped into three steps (the first two options, the next three, and the last two). The answer instructions required the examinee to consider their perception of the research activities. The score was obtained using all items and adding or averaging the responses. The interpretation was linear, where the increase in the score indicated a greater intensity of perceived competency. In reported studies of adaptations for health interventions, internal consistency has tended to be high ($\alpha > 0.80$) [34–38,40].

Study Satisfaction Scale—Brief (SSS-B) [50]. This scale identifies the students' degree of general satisfaction with participation in the academic activities in their universities. It comprises three items that quantify their satisfaction with general performance, studying, and studies. Some research works have been reported, and their results expanded into the construct validity of the BSSS with procrastination measures and its content equivalence among men and women [56]. In the present study, the internal consistency for the total sample was $\alpha = 0.71$ (Bootstrap 95% CI = 0.63, 0.78).

Single-Item Social Support—Revised (SSS). This single-item measure used to quantify tangible social support derived from the proposal by Blake and McKay [57]. It refers to the social network or structural support identified as the number of people available in problematic situations [58]. Initially, the item was constructed for its application in epidemiological studies, with the following content: "*How many close people do you have, upon whom you can really count, if you need help (for example, taking care of children or pets, being taken to the hospital or shopping, providing help if sick)?*" However, the original item was

modified to reduce the possible differential functioning in men and women detected in the childcare situation [57]. To express generic examples with little effect due to the differential functioning, we modified the item to: "*How many people close to you do you have, upon whom you can really count, if you need help (for example, if you are sick, shopping, etc.)?*" The response options were not modified and consisted of the four original options: *1 person*, *2 to 5 people*, *6 to 9 people*, and *10 or more people*. Although for descriptive analyses, responses to the SSS can be categorized into two (low social network: 1 person, and high social network: >2 people) [57]. The full range of responses was used for this study.

Generalized Anxiety Disorder-2 (GAD-2) [59]. Self-report scale included a short four-item measure of psychological distress. It was designed to identify the frequency of the main symptoms of generalized anxiety disorder, with two items questioning the presence of anxiety and worry in the subject during the last two weeks. It uses an ordinal format of four response types, from "*not every day*" to "*almost every day*." In the present study, reliability was acceptable ($\alpha = 0.72$; Bootstrap 95% CI = 0.62, 0.79).

Single-Item Self-Esteem Scale (SISE) [60]. Evaluates global self-esteem through a single item (i.e., "*I have high self-esteem*"); it is scaled ordinally, according to the degree of agreement (*Strongly disagree*, *Disagree*, *Between one and the other*, *Agree*, and *Strongly agree*). It was created as an alternative to the more extensive self-esteem measurements. There is strong evidence of its convergent and divergent validity with more than 20 behavioral and personality criteria [60–62], finding that the SISE is an indicator of general self-esteem sufficient for research and group descriptive purposes. In Peruvian adults, there is evidence that corroborates the validity of their scores [63,64].

Sociodemographic questionnaire. A form was developed with questions that investigated data on gender, chronological age, place of birth, and others whose percentages were reported here.

2.3. Procedure

Instrument development. The content base of the RPCS originated from the rational evaluation of previous research on using the PCS [32,35], where the pattern of content changes was adapted to the studied contextual theme. Therefore, no new items were created, but the PCS content was adapted for the perceived competency of participating in scientific research. As the objective of the instrument was to identify the level of perceived competencies in research activities in general, the modification consisted of (1) emphasizing a general perspective of tasks that the scientific research process usually involves, (2) maintaining content initially sampled by the relevant theory, on the perception of self-confidence, capacity, goal orientation, and overcoming challenges, (3) introducing changes in the specific content of the items per the objective, and (4) preserving the number of items of the original scales.

For the elaboration of the content of the RPCS, we considered: (a) that developing sampled content for specific research tasks would create an extensive instrument not recommended for massive evaluations; (b) using a parsimonious instrument with a general perspective of the perceived competency, which subsumes all the specific tasks; (c) a general content that links all the research tasks involved, aligned with the general approach of PCS applications in other areas such as earlier studies. These criteria should be maximized with the practical value of their use, i.e., reduced time to complete, low cost, and comprehensibility [65]. After a review of the literature on good translation practices [65–68], several general steps were deduced to start adapting the PCS to the context of research activities, starting with translation from English to Spanish.

After an independent search by two authors of the present study (C.M.-S. and M.F.-A.), which turned up no translation of the items, the adaptation of the PCS began with the translation from English to Spanish. First, all authors identified and agreed upon the new context of the PCS (i.e., scientific research activities). Second, the items were translated into Spanish by one of the authors, and in this translation, content changes were incorporated to adapt them to the new context. Third, two research psychologists independently reviewed

the translation and were instructed to focus on non-regional phrasing and non-literally interpreted content. During this review, the translators' questions were minor and resolved in one meeting; all were considered independently. Both translators indicated that the translated content could be interpreted without direct reference to a specific Hispanic population and directly into the new use context.

As a result of the preceding, the first modification was aimed at changing the RPCS response instructions, with the following content: "*Please, respond to each of the following statements according to the degree to which they are true for you, regarding performing scientific research activities.*" The second modification consisted of adding explicit references to the sampled contents of the PCS, obtaining the following items: "*I feel confident in my ability to carry out research activities*" (Spanish: "*Siento confianza en mi habilidad para hacer las actividades de investigación*"), "*I feel capable of carrying out necessary research activities*" (Spanish: "*Me siento capaz de realizar las actividades de investigación necesarias*"), "*I have ability to achieve goals that are set when doing research*" (Spanish: "*Tengo habilidad para lograr las metas que se plantean al hacer una investigación*"), and "*I feel that I can face the challenge of doing research activities well*" (Spanish: "*Siento que puedo enfrentar el desafío de hacer bien las actividades de investigación*"). Other structural aspects were maintained to facilitate comparability with the line of research with the PCS, for example, the scaling of the answers (seven options), their grouping (three labels, *Not at all true*, *Somewhat true*, *Very true*), and the ordering of the content sampled in the items (starting from confidence to facing the challenges).

Data recollection. After carrying out the respective coordination (among others, requesting authorization) with the relevant university directors, the tests were administered in their classrooms. The authors and collaborators of the application (e.g., collaborating researchers) gave standardized instructions regarding the form of response, the purpose of the research, the confidential nature of the results, and voluntary and anonymous participation. The instrument package was kept in the same order, and the first document was the informed consent, whose response conditioned the students' participation.

Ethical Considerations. This study is a part of a research project (HIM/2015/017/SSA.1207; "Effects of mindfulness training on the psychological distress and quality of life of the family caregiver") approved by the Research, Ethics, and Biosafety Commissions of the Hospital Infantil de México Federico Gómez, National Institute of Health, in Mexico City. The ethical rules and considerations regarding research with humans currently enforced in Mexico [69] and those outlined by the American Psychological Association [70] were followed. All participants were informed of the research's objectives, scope, and rights under the Declaration of Helsinki [71]. The participants who agreed to participate in the study signed an informed consent letter. Participation in this study was voluntary and did not involve payment.

Analysis. The quantitative study focused on obtaining evidence supporting content validity (the univariate properties of the items), the internal structure, the differential functioning of the items, internal consistency, and validity concerning other constructs. The analysis's general strategy was to apply several approaches to reduce the dependence of the conclusions on a single analytical procedure [72,73].

Content irrelevant responses. Potential careless responses were evaluated, as surveys applied in person or via the web platform have generally been associated with this unrelated pattern [74,75]; they can commonly be expressed as multivariate outliers [74,76]. To identify this problem, we used the D^2 distance [77], and to corroborate this identification, we calculated the *intra-individual response variability* (IRV) [74]. Both are efficient techniques for this problem [76]. This analysis was made with the R package *Careless* [78].

Item analysis. A descriptive analysis of the items' distributional, correlational characteristics and the response trend was made using non-parametric procedures due to the ordinal level of the responses [79]. The analyses were conducted with the *Langtest* [80] and *MVN* [81] R packages.

Non-parametric analysis. Before using latent variable modeling, we evaluated the RPCS' fundamental properties with the Mokken Scaling Analysis (MSA) [82,83], a non-

parametric framework for analyzing measurement properties based on direct scoring. It does not require the substantial restrictions of SEM modeling [82,84]. Four essential characteristics were explored [85]. The first three are fundamental for the score to work with monotone homogeneity (MHM): *scalability* (using the H coefficient), *local independence* (item responses are not mutually influenced), and *monotonicity* (incremental function between item and latent attribute, evaluated by comparing the actual and expected number of violations to the monotonic model). The fourth characteristic, linked to the invariant item order (IIO) model, was the differentiated response function of the item response options [85]. The analysis was performed with the *Mokken* package [84,86].

SEM analysis. After the MSA non-parametric analysis, dimensionality was evaluated parametrically with confirmatory factor analysis for categorical data, with the *weighted least square mean and variance adjusted estimator* (WLSMV) [87]. Dimensionality fit was assessed with approximated indices: *CFI* ($\geq$0.95), *TLI* ($\geq$0.95), *RMSEA* ($\leq$0.05), and *SRMR* ($\leq$0.05). The R package used was *Lavaan* [88].

Differential item functioning. To verify item differential functioning, which is equivalent to measurement invariance from a non-parametric approach in categorical variables, we applied the partial gamma coefficient (γ^{P}) [89] using the magnitude levels in weak (0.00 to 0.150), moderate (0.16 to 0.30), and strong (>0.31). There are general interpretation suggestions for this coefficient (e.g., >0.60: strong > 0.30: moderate, and $\leq$0.30: weak) [90], but the former tends to be commonly applied in the study of IDF. The R package used was *Iarm* [91].

Reliability. Reliability was estimated at the item level and score level. Regarding the item level, we used the attenuation-corrected coefficient [92], given its lower bias and computational ease [93]. The minimum acceptable value is around 0.30 [94]. For score-level reliability, we used the MSrho coefficient [95], derived from non-parametric modeling MSA; and linear SEM modeling, ω for categorical variables [96]; the α coefficient was also estimated.

Association with other variables. To obtain validity evidence of students' satisfaction with their academic studies (SSS-B score) and anxiety symptoms (GAD score), we applied a hierarchical multiple linear regression analysis, in which the semi-partial correlation (r_{sp}) was used as the effect size [97] of the single RPCS contribution, adjusted for the effects of gender, semester, and tangible social support (SSS score). Here, the Bodner proposal [98] was followed to qualify the semi-partial correlations as trivial (<0.14), small ($\geq$0.14), moderate ($\geq$0.42), and large ($\geq$0.71). The R package used was *Lm* (R Core Team, 2021).

3. Results

3.1. Descriptive Analysis

Preliminary Analysis. Three cases were detected with D^2 values higher than the established nominal level of 0.01 (i.e., F (4,305) = 25.05) (74.73, 57.18, and 44.72, respectively); and one case (D^2 = 22.78) was detected at the nominal 0.05 level (F (4,305) = 21.81). The inspection of these first three cases showed an inconsistent response pattern (e.g., some items were answered with answer option 1 while the rest had responses around answer option 5), but the last one did not seem to fit an inadequate pattern. These results coincided with individual variability (IRV); therefore, these three subjects were removed from the database.

3.2. Psychometric Analysis

Item analysis. Results are shown in Table 1. Item response trends, according to the reported measures, generally around answered point 4, but they were statistically different: Friedman-χ^2(3) = 45.96, $p < 0.01$ approximated between small and moderate discrepancy (r_{total} = 0.35, 95% CI [0.25,0.45]). Post-hoc differences (Wilcoxon test, two dependent samples) occurred between items 2 and 3 (Wilcoxon test = 2956, z = 2.63, r = 0.11, 95% CI [−0.01,0.22]) and 3 and 4 (Wilcoxon test = 1737.5, z = 0.990, r = 0.04, 95% CI [−0.07,0.15]), which can be considered small differences between these items. Regarding the distribution,

the items showed varying magnitudes of skewness and kurtosis, but they were similar concerning their distributional trend. Only items 3 and 4 did not fit the theoretical normal distribution ($K^2 > 9.0$).

Regarding the correlations, we observed that the covariation between the items was high, varying between 0.81 and 0.89, indicating approximately 71.6% of common variance. This inter-item correlation matrix was statistically different between its items (Lawley-$\chi^2(5) = 65.05$), although the difference between the minimum ($z = 1.12$) and maximum ($z = 1.41$) correlation was relatively small ($q = 0.292$; Cohen, 1992). The gender test (Jennrich-$\chi^2(6) = 9.35$, $p > 0.10$) showed the similarity of this correlation matrix.

As for sociodemographic variables, all items displayed a similar correlational pattern of magnitude and direction; with age and gender, the magnitude was positive but essentially small. About gender, the negative correlations were due to coding effects in that males tended to score slightly over females. Regarding the academic semester, the covariation was essentially zero.

Table 1. Item descriptive and correlation statistics.

Descriptives								
	RPCS1		**RPCS2**		**RPCS3**		**RPCS4**	**Total**
M	4.62		4.75		4.87		4.91	19.15
SD	1.40		1.37		1.37		1.38	5.18
Skew.	−0.21		−0.29 *		−0.26		−0.47 *	−0.25
Kurt.	−0.26		−0.27		−0.55 *		−0.14	−0.31
K^2	3.18		5.26		10.14		11.15	4.54
Correlations								
	RPCS1	**RPCS2**	**RPCS3**	**RPCS4**	**Age**	**Gender**	**Semester**	**SISE**
RPCS1	1				0.14 *	−0.20 **	0.02	0.23 **
RPCS2	0.89 **	1			0.17 **	−0.20 **	0.001	0.29 **
RPCS3	0.82 **	0.84 **	1		0.18 **	−0.15 **	0.005	0.25 **
RPCS4	0.81 **	0.83 **	0.88 **	1	0.15 **	−0.11 **	0.01	0.24 **
Total Score	–	–	–	–	0.18 **	−0.20 **	0.003	0.21 **

Note. Skew: Skewness. Kurt.: Kurtosis. K^2: D'Agostino normality test. SISE: Single-Item Self-Esteem scale. RPCS1, RPCS2, RPCS3, RPCS4: items from Perceived Research Competencies Scale. * $p < 0.05$. ** $p < 0.01$.

3.3. Internal Structure Evidence

Non-parametric modeling (Mokken Scaling Analysis). Table 2 displays the results of this non-parametric modeling. It can be observed that items consistently maintained high magnitudes regarding their scalability ($H > 0.82$). Similarly, the inter-item scalability distribution ranged from 0.82 to 0.91 (not shown). For the total score, H was also higher than 0.82, (*s.e.* = 0.022; 95% CI [0.81,0.90]). In the test of local independence, the W_1 index varied between 0.59 and 2.55; with W_2, it varied between 9.99 and 12.05; and with W_3, it varied between 0.54 and 5.59. Consistently, the results did not indicate significant magnitudes of local independence violations between the items. No violations were detected when the monotonicity and invariant item ordering (IIO) models were examined (see Table 2). The estimated reliability with the MS coefficient was 0.95. In summary, the RPCS items and score adequately satisfied scalability, local independence, monotonic item–score relationship, and invariant ordering across scores. Additionally, the item–test correlations were high (>0.80).

Table 2. Non-parametric (Mokken Scaling Analysis) and linear model results.

	Mokken Scaling Analysis (MSA)									
	H	**Monotonicity**			**IIO**			**Linear Modeling**		
		#vi	***#z***	***crit***	***#vi***	***#z***	***crit***	R_{itc}	***F***	r_{ii}
RPCS1	0.86	0	0	0	0	0	0	0.81	0.95	0.68
RPCS2	0.86	0	0	0	0	0	0	0.84	0.94	0.73
RPCS3	0.86	0	0	0	0	0	0	0.82	0.94	0.70
RPCS4	0.83	0	0	0	0	0	0	0.81	0.91	0.68
Total	0.85	–	–	–	–	–	–	–	–	–

Note. *H*: Scalability coefficient. *IIO*: Item Invariant Ordering. *#vi*: Number of model violations. *#z*: Number of statistically significant violations. *crit*: Combined count of *#vi* and *#zsig*. *F*: factor loading. R_{itc} = item–test correlation. r_{ii}: item reliability. RPCS1, RPCS2, RPCS3, RPCS4: items from Perceived Research Competencies Scale.

Parametric modeling. The linear fit to the one-dimensional RPCS model was satisfactory: WLSMV-$\chi^2(2) = 31.28$, $p < 0.01$, *CFI* = 0.999, *SRMR* = 0.024. Specific item parameters (Table 2), in relation to the factor loadings ($\lambda > 0.89$) and explained variances ($h^2 > 0.81$) were statistically significant ($z > 75.00$) and high. These factor loadings indicate a strong relationship between the items and their construct. Due to the magnitude of these parameters and the fit indices, no modifications were introduced to improve the model. The tau-equivalent model (equal factor loadings, estimated at 0.94) had a slightly lower fit than the unrestricted model (congeneric model), WLSMV-$\chi^2(5) = 42.98$, $p < 0.01$, *CFI* = 0.99, *SRMR* = 0.029; however, the scaled difference between both models was statistically significant (ΔWLSMS-$\chi^2(3) = 20.33$, $p < 0.01$).

3.4. Internal Consistency

With the total sample, the internal consistency ω was 0.96 (bca bootstrap 95% CI [0.95,0.96], *s.e.* = 0.005), while the internal consistency α was 0.96 (bca bootstrap 95% CI = [0.95,0.96], *s.e.* = 0.004). Both yielded indistinguishable values and were high in population terms. In the items, the reliability for each one was greater than 0.65 and similar. They can all be considered as units with appropriate individual consistency.

3.5. Item Differential Functioning

Results are shown in Table 3. With the academic semester grouping variable, the homogeneity of the γ^p coefficients in the score strata was established ($\chi^2 < 9.0$, $p > 0.10$). The point estimate of γ^p and its confidence intervals had trivial magnitudes and included the parameter 0, respectively, indicating that the magnitude of DIF was predominantly trivial and not statistically significant. With the general self-esteem variable (SISE), homogeneity was achieved on items one through three but not on item four. In item four, score 3 was the level at which strong γ^p occurred (.71, 95% CI [0.50,0.93], $p < 0.01$), very discrepant from the rest of γ^p of each stratum (between -0.42 and 0.33), but none were statistically significant. In items one and three, γ^p was not statistically significant, having a trivial magnitude. Its confidence intervals indicated that its population variation might be substantial. Its negative orientation suggests that the proportion of responses is dissimilar between the semesters. On the other hand, items two and four demonstrated statistically significant, strong coefficients (i.e., between 0.35 and 0.45), and their population variation can produce small coefficients. The interpretation of γ^p in item four should be taken with caution due to the slight heterogeneity of γ^p across RPCS score strata.

Table 3. Non-parametric analysis of item differential functioning (partial gamma coefficient).

	Semester			General Self-Esteem (SISE)		
	γ^p	γ^p 95% CI	Homogeneity χ^2 (df)	γ^p	γ^p 95% CI	Homogeneity χ^2 (df)
RPCS1	0.12	−0.04, −0.28	7.52 (8)	−0.18	−0.37, 0.013	4.86 (7)
RPCS2	−0.08	−0.27, 0.10	5.25 (8)	0.44 **	0.27, 0.61	11.73 (8)
RPCS3	0.02	−0.18, 0.21	3.72 (6)	−0.10	−0.32, 0.12	4.90 (7)
RPCS4	−0.10	−0.28, 0.07	8.86 (7)	0.36 **	0.20, 0.51	26.13 (7) **

Note. γ^p: Partial gamma coefficient. SISE: Single Item of Self-Esteem. RPCS1, RPCS2, RPCS3, RPCS4: items from Perceived Research Competencies Scale. df: degree free.** $p < 0.01$.

3.6. Association with Other Variables Evidence

Results are shown in Table 4. Regarding satisfaction with studies (SSS-B score), the baseline model, with gender, semester, and tangible social support (SSS score) as predictors, was not statistically significant: $F(3, 249) = 0.66$, $f^2 = 0.1$ (small effect) [99]. The inclusion of the RPCS produced explained variance beyond the sampling error, $F(4, 248) = 2.843$, $p < 0.01$) with a moderate effect size ($f^2 = 0.26$). The raw difference from baseline variance ($\Delta = 0.04$) was statistically significant: $F(1, 248) = 9.31$, $p < 0.01$. The magnitude of this localized difference, relative to the baseline model [100], was approximately moderate ($f^2 = 0.15$).

Regarding anxiety symptoms (GAD-2 score), the model in block 1, with the predictors of gender, semesters, and tangible support (SSS score), the model with the PCRS (F [4,247] = 5.86, $p < 0.01$) presented a large effect size ($f^2 = 0.42$), while without the PCRS, it was approximately moderate ($f^2 = 0.30$; F [3,247] = 4.73, $p < 0.01$). The difference with the baseline variance ($\Delta_{R^2} = 0.033$) [100] was statistically significant $F(1, 246) = 8.83$, $p < 0.01$), and had small local magnitude ($f^2 = 0.087$). According to the semi-partial correlation ($r_{sp} = 0.19$), 3.5% is the amount of unique contribution of the perceived competency to investigate general anxiety symptoms (GAD-2).

Table 4. Hierarchical regression to estimate validity.

Dependent Variable	Study Satisfaction (BSSS)			Anxiety Symptoms Score (GAD-2)		
	Step 1	Step 2		Step 1	Step 2	
R^2	0.09	0.21		0.23	0.30	
	β	B	r_{sp}	β	B	r_{sp}
Gender	−0.03	0.006	0.006	0.12	0.08	0.08
Semester	0.08	0.08	0.08	−0.21 **	−0.20 **	−0.20
Tangible support (SSS)	0.03	0.03	0.03	0.01	0.02	0.02
RPCS	–	0.19 **	0.19	–	−0.19 **	−0.18

Note. RPCS: Research Perceived Competencies Scale. BSSS: Brief Study Satisfaction Scale. GAD-2: Generalized Anxiety Disorder-2. SSS: Single Item Support Scale. r_{sp}: semi-partial correlation. ** $p < 0.01$.

4. Discussion

The study's objective was to evaluate the psychometric properties of the Perceived Research Competencies Scale, a construct developed to conceptually approximate undergraduate students' motivation for research. Regarding the internal structure, a high linear relationship was found between the items (>60% of shared variance). This finding could indicate redundancy in the content because its contents may present repeated behaviors phrased differently. However, the content was derived from the original version with few modifications, and they expressed variations of behavior that concurred with each other. Since the instrument's constitution was adapted similarly in other situations (see cited literature), the variant made here was an extension of the possible versions in different behavioral areas. The changes to the instrument served to contextualize students' self-reporting appropriately.

Given the high statistical similarity between items in almost all the parameters (e.g., factor loadings, distributions, and variability), obtaining a measure based on a single item could be considered. Evaluation using a single item of a construct is recommended when it is unidimensional and with similar psychometric properties between the items in a complete measurement [101]. As these characteristics appear to be fulfilled by the RPCS, choosing an item that is psychometrically interchangeable with the rest but sensitive to criteria of interest in research or self-efficacy and involvement in research activities seems feasible.

The high inter-item correlations may not seem surprising for several reasons: the small number of items, the tendency to high inter-item covariation in other studies, and the high specificity of the measured construct. However, empirical verification is required not only to ensure the dimensionality of the measure but also to identify other psychometrically relevant characteristics. One explored in the present study was the psychometric similarity of the items (tau-equivalence), in which a discrepancy was found between statistical identification and its practical consequence. Although the tau-equivalent model was statistically inferior to the congeneric model (i.e., unconstrained factor loadings), this did not impact the internal consistency estimate made by the α coefficient in any serious manner. Usually, the discrepancies in the magnitude of the factor loadings between the items decrease the alpha coefficient's size [96]. Nevertheless, in the present study, the alpha was not different from the omega coefficient. Therefore, the α coefficient can be calculated with little risk of underestimating it because the items similarly represent its construct.

Regarding item differential functioning, this did not seem to be associated with psychometric differences caused by the semester of study because the relationship between the two was trivial or around zero. This conclusion implies that if there are variations in perceived competency among students, these variations are mainly due to variations in the latent construct. On the other hand, general self-esteem did produce differential functioning in two items ("*I feel capable of carrying out the necessary research activities*" and "*I feel that I can face the challenge of doing the research activities well*") at levels that varied between small and large; this variation occurred among those with higher self-esteem. This finding indicates that both items can co-vary with self-esteem even by keeping the research competencies constant. Presently, it is not clear how these specific contents of the new instrument function differentially concerning generally perceived self-esteem. Still, self-esteem is an identifiable moderator that should be considered in future studies to investigate the differential functioning of items. Other studies [102,103] have verified its moderating impact, and it may be a variable that requires further research.

While estimating the RPCS' validity concerning students' satisfaction with undergraduate studies, we found a significant statistical and positive contribution when the variability of the students' gender, semester of study, and tangible support were controlled. This discovery suggests that experiencing student satisfaction with undergraduate studies is linked to at least two things: (a) students' perceived effectiveness when participating in research activities and (b) the experiences associated with it. If one characteristic that describes an educational institution is the student's satisfaction with their behavior, then it is apparent that the experiences of effective participation have an explanatory role in this emotional experience. On the other hand, the RPCS also contributed independently to the intensity ($r_{sp} = -0.18$, 3.2%) and direction (i.e., negative correlation) of anxious symptomatology and positively to students' satisfaction with undergraduate studies. Both results suggest that perceived competency in research contributes to a small extent to reducing general anxiety behavior, possibly caused by the link between anxiety and academic performance [52].

Due to these psychometric validity findings, the perceived competency to undertake research, estimated by the new instrument (RPCS), maintained theoretically consistent relationships of university student behaviors aligned with the literature that directly or indirectly links perceived research competency with anxiety [12]. Due to the link between motivation and perceived competency [10], the latter can promote the students' enjoyment

of research courses, increased effort to complete assigned tasks, and possibly a persistent orientation to achieve academic goals.

One association was the linear link between perceived self-efficacy scores for research and tangible social support. It can indicate that students perceive the importance of people's assistance and their (quantitative) availability to provide support at the needed time. This moment potentially includes those involved in academics on and off-campus and the social experiences and the consequent benefits. Indeed, there is evidence that available tangible support linearly relates to health effects [104].

The present study implies that evaluating motivational factors in research teaching, such as perceived competency, can help monitor the acquisition of student research competencies in developing research projects and writing publishable manuscripts [2,9]. In this way, and employing the RPCS, the change between training periods in research skills, the establishment of a baseline, and the variability of perceived research competence in multilevel groupings can be measured. Another implication is that this study adds theoretical content to constructing the perceived research competency as fertile for research and teaching research skills. Indeed, the initial results of this study define a construct directly derived from a motivational approach that can be added to the intra-individual variables to explore research interest and participation. Because this construct is derived from a model with apparent cross-cultural validity, research-perceived competency may also be cross-cultural. Finally, another implication is that these competencies can be integrated into the objectives of high-impact experiences aimed at stimulating engagement with individual and institutional goals, depth and breadth of learning, and collaboration [49,105,106]. This scope of activities is an opportunity possibly not exclusive to the context of the present study sample (Peru) but rather is universal in the university setting.

The results of this research may lead the user to consider the adapted instrument as feasible, i.e., it meets several characteristic practices that make it an ideal measurement: reduced time to completion, low implementation costs, and comprehensibility [65]. The latter is maximized because a) the new context of using the PCS for student research activities is not foreign to students, and they can connect directly with the content of the RPCS, and b) during the process of construction (translation and adaptation) and administration to the students in the sample, questions and concerns about its interpretability and clarity were of low severity and insubstantial. On the other hand, the RPCS maintains high factor loadings (>0.70) [107], an indicator of the strength of item validity in the construct measured.

As a corollary, the measurement instrument developed here was brief. One can reasonably induce that there is little likelihood of significant changes in the magnitude of the factor loadings because they are high (>0.70) [107], and the interaction between the small number of items may reduce the capitalization of chance. However, the optimal results need to be evaluated for safe generalization [108,109].

The findings obtained must be interpreted based on their limitations. First, the sampling of the participants does not ensure their population representativeness. Therefore, the generalization of the descriptive and correlational information can only indicate the variability of the constructs in the sample. Second, the sample size needs to be more significant to strengthen the stability of the results. Third, a measure of social desirability was not included; consequently, the extent to which this attribute added irrelevant systematic variance cannot be estimated.

5. Conclusions

This study developed a new adaptation of a perceived competencies measurement instrument focused on research skills: the Research Perceived Competencies Scale (RPCS). The RPCS was applied to a sample of undergraduate students, and good internal structure properties were obtained and evaluated by non-parametric and parametric methodologies. Specifically, the RPCS showed strong item relationships (high factor loadings) with its latent construct, a high level of internal consistency reliability at the score level (greater than 0.90) and the item level (greater than 0.50), and theoretically coherent associations,

with associations close to zero in demographic aspects (gender, age, and semester of study), and low but statistically significant correlations in general self-esteem. Differential item functioning was non-existent or low magnitude for some items, influenced by perceived general self-esteem. The items in this new version have statistical similarities in their distribution and function as a unit but with non-redundant content. The RPCS score is associated with study satisfaction and general anxiety symptoms. The brevity of this instrument, and the satisfactory validity evidence obtained, indicate that this new adaptation can significantly contribute to the teaching of research and the efficiency of student participation in research activities.

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