Journal of Education and Learning; Vol. 13, No. 4; 2024
ISSN 1927-5250 E-ISSN 1927-5269
Published by Canadian Center of Science and Education

Development of a Scale of Skills in Teaching Work and Innovation in University Education

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Received: January 2, 2024 Accepted: March 2, 2024 Online Published: April 14, 2024

doi:10.5539/jel.v13n4p96 URL: https://doi.org/10.5539/jel.v13n4p96

Abstract

This study aimed to validate a scale for subjectively measuring teaching competencies for innovation in higher education. The scale was developed by creating a set of items that underwent content validity through the Delphi technique and face validity. A survey was then conducted with 523 higher education professors. The resulting scale, called the STW-ICE Scale, consists of four dimensions: continuing education, creativity, digital fluency, and scientificity. We found that the scale has psychometric properties that allow for subjective measurement of the proposed competencies. The SmartPLS and SPSS software were used for data assessment. Additionally, we found high levels of teaching skills in the sample for all dimensions. Based on these findings, this study successfully achieved its goal of developing and validating a scale. We hope that this scale will be used not only for classificatory diagnoses but also to encourage reflection on teaching practices in higher education with a focus on innovation.

Keywords: teaching skills, innovation, higher education, teaching work

1. Introduction

The new demands of society require educational institutions, especially higher education institutions, to promote the use of new teaching and evaluation methods that correspond to the dynamic scenario (Alcívar, 2018). In this context, technological resources support access to large quantities of technical and scientific information and collaborative tools that enhance university students' learning (Araya-Muñoz & Majano-Benavides, 2022). This is supported by data from the Brazilian Higher Education Census from 2010 to 2020, which showed an increase in the number of admissions driven by a positive variation of 428.2% in distance learning courses, necessitating a massive use of technology for teaching. However, face-to-face undergraduate courses experienced a negative variation of 13.9% (Brasil, 2020). With the increase in the number of slots in education and the context of a network society, the diversity found in Brazilian classrooms has also been growing and poses another challenge for teaching.

Given this perspective, the reality of higher education institutions is related to the social, cultural, and economic demands in which they are inserted; in turn, professors require various competencies that meet the demands of the current university education scenario (Manzanal Martínez et al., 2022). In addition, higher education institutions (HEI) influence and are influenced not only by local aspects but also by global ones. Thus, the concept of a multifaceted reality is characterized by an emerging context and requires innovations (Corte, 2017). Additionally, the COVID-19 pandemic has generated a scenario with profound changes in the ways of teaching, with greater interaction and use of information technologies via remote classes (Ratten, 2023).

Establishing competencies and their relationships requires a foray into the discourse and actions of the individuals at the head of organizational processes and structures and an understanding of their behavior and knowledge of the context in which they are inserted. Competencies have been the focus of researchers from many different areas of knowledge, with their initial conceptualization coming from the organizational area and later adoption by the educational field (Prahalad & Hamel, 2006; Dutra, 2008; Mulder et al., 2009; Zabala & Arnau, 2015; Trentin & Trantin, 2022).

In order to innovate in education, several guidelines must be set; otherwise, we will distort the objective and not make any progress. It is noteworthy that numerous organizational areas need to implement an innovation process that is constantly evolving and improving people, processes, systems, and ways of managing. Especially in the educational context, implementing innovation processes aims to ensure that environments are conducive to learning, student protagonism, and meaningful learning (Alcívar, 2018). Strengthening basic, technical, and technological competencies creates multiplying and innovative spaces for the whole learning environment and promotes diversified teaching (Araya-Muñoz & Majano-Benavides, 2022).

Studies have shown that professors must have the knowledge, skills, attitudes, and competencies to act amid the complexity of teaching in higher education, which involves conflicts and social, political, and economic changes (Miranda & Santos, 2018). The literature also indicates that these professionals must manage heterogeneous groups, work in teams, constantly innovate, and promote objective communication with peers and students (Manzanal Martínez et al., 2022).

However, given the new challenges that have emerged, including distance learning, which was made easier during the pandemic, and artificial intelligence and its various forms and limitations of use (Lim et al., 2023), more dimensions must be addressed. Therefore, it is highly relevant to validate and test an instrument useful in evaluative and particularly formative terms, especially amid so many changes. In this context, we ask, "What are the necessary teaching competencies to innovate in higher education?"

It is important to note that we do not intend to definitively and immutably answer the research question, as the aim is to reflect on teaching practices in a constantly changing society, where neoliberal logic permeates institutions and public policies are not immune to this dynamic. In light of the above, the main objective of this study was to propose and validate a scale to subjectively measure teaching competencies for innovation in higher education.

2. Contextualization of the Proposed Hypotheses

The proposed scale of competencies in teaching work and innovation in higher education consists of four dimensions: continuing education, digital fluency, creativity, and scientificity. In order to provide context for the relationships between these dimensions, this study will first introduce the authors' concepts and principles.

Continuing education refers to the ongoing need for professors to update their pedagogical knowledge and skills. This includes integrating new teaching and learning methods, which may involve creative approaches to education in higher institutions (Yuldasheva & Kadirova, 2020). Creativity in the classroom enhances teaching by making it more engaging and encouraging students to think critically and solve problems independently. In the context of continuing education, creativity refers to the ongoing development and updating of knowledge. Concerning scientificity, continuing education involves professors' skills in scientific research and applying scientific principles in teaching. This promotes critical thinking and scientific knowledge among students (Alt et al., 2023).

Innovation in higher education depends on quality continuing education, which integrates both creativity and scientificity and can promote innovation in higher education as professors incorporate new teaching strategies, adapt to the changing demands of the labor market and society, and prepare students to be critical and innovative thinkers (Portuguez-Castro et al., 2022). In this context, hypothesis 1 and 2 emerges:

H1 and **H2**: Continuing education positively influences creativity and scientificity.

Digital fluency is an essential competency in teaching work and, when applied creatively and scientifically, can significantly underpin innovation in higher education. Digital fluency interacting with creativity is about professors' abilities to integrate digital technologies into their teaching practices inventively and effectively through interactive apps, educational games, and virtual or augmented reality platforms, among others, to make learning more engaging and personalized (Abduraxmanov, 2022).

Creativity in digital fluency can also involve devising new methods for using technology in the classroom to better meet learners' needs. Its interaction with scientificity implies the ability of teachers to understand, evaluate, and apply relevant research and data in educational technology. They can use learning data to adapt their teaching to the individual needs of learners or apply research on the effectiveness of different teaching technologies (Sopapradit, 2022).

Scientificity in digital fluency also requires understanding the scientific principles behind the technologies used and the ability to teach these principles to learners. Combining creativity and scientificity in digital fluency may lead to significant innovation in higher education, as professors who creatively and scientifically implement technology in their teaching practices may develop more effective and engaging learning methods (Li & Yu,

2022; Sindarova et al., 2022). In this sense, we also put forth hypotheses 3 and 4:

H3 and **H4**: Digital fluency positively influences creativity and scientificity.

Creativity and scientificity are two important dimensions that intersect in many teaching work aspects, especially when considering innovation in higher education. Creativity, in the context of teaching work, involves imagining and implementing new teaching and learning methods. This may involve creating innovative classroom activities, adopting emerging technologies to assist learning, or applying new pedagogical strategies that motivate and engage students more effectively (Anderson et al., 2022; Weng et al., 2022). Creativity is essential for innovation in higher education as it enables professors to respond to learners' changing needs and society.

Conversely, scientificity refers to professors' abilities to approach teaching and learning from an evidence-based perspective, and this may involve applying continuous research-based learning theories, conducting research to assess the effectiveness of new teaching methods, or understanding and incorporating the latest advances in the field of education (Andrews et al., 2022; González-Pérez & Ramírez-Montoya, 2022). Moreover, scientificity allows professors to validate their creative approaches and ensure they adopt effective strategies (Dervenis et al., 2022).

The relationship between creativity and scientificity in teaching work is, therefore, one of complementarity, meaning that while creativity enables professors to imagine new forms of teaching and learning, scientificity enables them to assess these approaches' effectiveness. Together, both dimensions are fundamental to innovation in higher education (Huang et al., 2023). These previous studies lead to hypothesis 5:

H5: Creativity positively influences scientificity.

3. Materials and Methods

3.1 Aims

This study assessed the potential competencies of university professors and their ability to innovate in the face of new teaching perspectives that emerged during the COVID-19 pandemic.

3.2 Study Design

This quantitative study has an exploratory and descriptive character and employed cross-sectional data and a survey for data collection. Data was collected from February to May 2022 using an online questionnaire applied to HEI professors from Brazilian public and private institutions.

3.3 Participants and Ethical Considerations

The professors were contacted via e-mail and social networks and sent an online questionnaire (Google Forms) and a free informed consent form. If they agreed to participate, they proceeded to answer the questionnaire. The data were collected from February to May 2022, justifying this period by reaching an acceptable, representative, and reliable sample to propose the model and analyze the results. A total of 523 professors answered the instruments; most participants were 41–50 years old, married, had PhDs, worked in public universities, and worked for 21–30 years in higher education with 40 hours of weekly activities.

This study was approved by the Research Ethics Committee (CAAE no. 44261821.8.0000.5346 and opinion no. 4.596.220). Through these methodological and ethical procedures, it was possible to successfully analyze the elements necessary to elaborate and validate a scale to measure teaching competencies for innovation and weave relationships with work engagement.

3.4 Measurements

Two questionnaires were utilized: one with sociodemographic questions and one with questions related to the proposed scale. The scale of skills in teaching work and innovation in college education (STW-ICE) (Appendix) proposed herein comprises four dimensions: continuing education (5 questions), digital fluency (5 questions), creativity (6 questions), and scientificity (9 questions) and were assessed using a 5-point Likert scale ranging from 1 (never) to 5 (always). To assess the intensities of the dimensions, we used the scale standardization (Ss_i) technique of Lopes (2018, p. 35). Professors gave ratings of low (0.00–33.33%), moderate (33.34–66.67%), and high (66.68–100.00%) as to the intensity of their competencies for innovation. Cronbach's alpha values for each of the scale dimensions were: continuing education ($\alpha = 0.764$), digital fluency ($\alpha = 0.791$), creativity ($\alpha = 0.803$), and scientificity (0.917), and the STW-ICE Scale ($\alpha = 0.887$).

3.5 Content, Face, and Construct Validity

Content validity is an essential procedure to verify the adequacy, relevance, and representativeness of the items of a measurement scale in relation to the dimensions it seeks to measure (Guillot-Valdés et al., 2022). Hair et al. (2009) described it as "assessing the degree of correspondence between the items selected to constitute a summated scale and its conceptual definition."

The Delphi method is used to systematize decision-making by a group of experts without direct interaction between them. It consists of a set of questionnaires answered individually in stages and, at each stage, summarizes the information from the answers of the previous versions. Thus, it is possible to gradually establish a consensus among collaborators (Osborne et al., 2003; Marques & Freitas, 2018).

In this study, through the Delphi technique, we proposed four dimensions and their respective items for the experts to judge their adequacy (Table 1). The dimensions, which are the competencies that gave rise to the items, are related in such a way that there is no order of importance in the constitution of the competencies.

Table 1. Definition of dimensions of skills in teaching work

Dimension	Description
Continuing education (Ce)	Updating knowledge and skills, adapting to technological changes, developing social-emotional skills, and promoting inclusive and equitable education.
Creativity (Cr)	Stimulating and engaging learning environments, diversified teaching strategies, stimulating problem-solving, and a culture of lifelong learning.
Digital fluency (Df)	Integrating technology with teaching, personalizing learning, online collaboration and communication, digital literacy, continuous professional development and learning, and engagement with learners and their families.
Scientificity (Sc)	Utilizing evidence-based approaches, developing skills and critical thinking, stimulating research and innovation, and promoting scientific literacy, responsibility, and ethics in education.

Face validity, or pre-testing, is necessary when measures are new or combine different sources; it consists of applying a pilot test to a group of respondents similar to the population that will be the survey's target. Thus, items with a statistical behavior that deviates from the expected should be adjusted or excluded from the final instrument (Hair & Alamer, 2022). This study applied the pilot test to 32 higher education professors.

To analyze the pre-test results, we conducted an exploratory factor analysis (EFA) using the bootstrapping technique. The EFA is used to reduce data and discover optimal weights for the variables so that many of these [weights] can be reduced to a set with maximum reliability (Laros, 2005). Based on the data, it was possible to construct validity using measurement invariance analysis between the professors' genders and the types of institutions. Construct validity assesses the adequacy of the instrument items to the theory through statistical tests (Hair & Alamer, 2022). Construct validity was carried out by structural equation modeling and multi-group analysis; it enables users to verify the model's results and generalize the data to different demographic groups; it is also consistently replicated for different contexts and populations (Millsap, 2012; Hagger et al., 2020).

3.6 Data Analysis

We used the software SPSS® (version 26) and Smart PLS® (version 4.0.9.9) to analyze the data from this study (Ringle et al., 2022). The number, percentage, mean, and standard deviation were used for descriptive analyses. Sociodemographic variables (gender and type of institution) were used to moderate the relationships between the dimensions of the structural model using partial least squares and multi-group analysis (Figure 1). We applied group comparison (Mann-Whitney) and normality tests (Shapiro-Wilk) to assess data behavior. The significance level was 0.05.

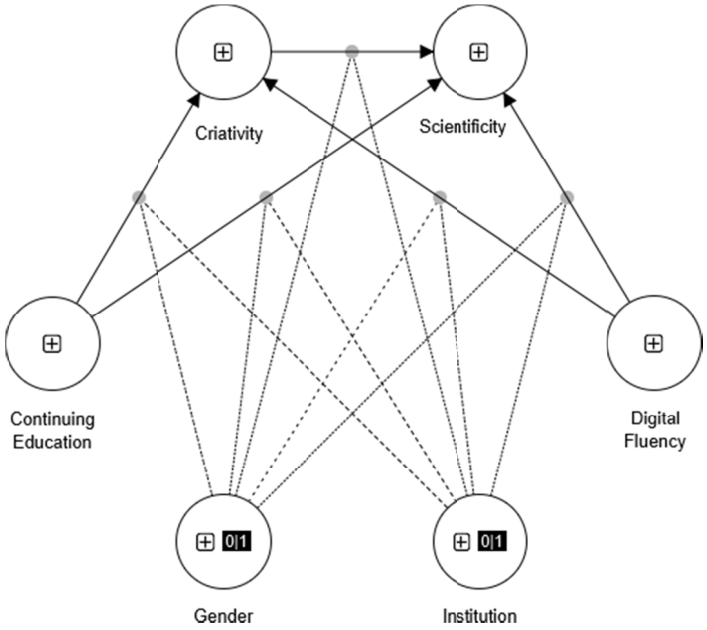

Figure 1. Variables included in the structural model and moderator variables

4. Results

4.1 Sociodemographic and Individual Characteristics of the University Professors

The sociodemographic characteristics of the participating professors are listed in Table 2. Both men and women (49.9%) responded to the survey; the mean age was 41–50 (31.9%), most respondents were married (68.08%), received a salary between BRL 10,000 to 20,000 (58.5%), and had a PhD (78.97%), no other professional activity (87.6%), and a ≥ 40 h/week workload (81%).

Table 2. Socioeconomic profile of the survey participants (n = 523)

Variables	Categories	Frequency	Percentage
Gender	Female	261	49.90
	Male	261	49.90
	Other	1	0.20
Age (years)	21–30	14	2.68
	31–40	139	26.58
	41–50	167	31.93
	51–60	141	26.96
	> 60	62	11.85
Marital status	Married	356	68.08
	Single	110	21.03
	Widow(er)/Divorced	57	10.69
Salary range (BRL 1,000)	< 5	20	3.82
	5–10	86	16.44
	10–20	306	58.51
	> 20	111	21.22
Level of education	Undergraduate degree	2	0.38
	Specialization	34	6.50
	Master's degree	74	14.15
	PhD	413	78.97
Sector of work	Public	464	88.71
	Private	54	10.33
	Both	5	0.96
Other professional activity	No	458	87.57
	Yes	65	12.43

Time in position (years)	≤ 3	40	7.65
	4–10	122	23.33
	11–20	170	32.50
	21–30	136	26.00
	> 30	55	10.52
Workload (hours/week)	≤ 20	42	8.03
	21–30	16	3.06
	3 –4 0	41	7.84
	40 (EC)	402	76.86
	> 40	22	4.21

Note. EC: Exclusivity contract.

Notably, one professor declared "other" for gender and five declared "mixed" for the type of institution; therefore, they were excluded from the sample.

4.2 Analysis of Invariance of the Scale of Skills in Teaching Work and Innovation

The results of the multi-group analysis are presented in Table 3. We used Henseler's nonparametric method to compare the structural coefficients between genders and types of institutions (Klesel et al., 2019; Cheah et al., 2023). There was no significant difference between genders and institutions when the hypotheses proposed to validate the scale were separated ($p > 0.05$). Therefore, the STW-ICE Scale presented structural validity.

Table 3. Results of the multi-group analysis: male vs. female and public vs. private university.

Hypotheses	Path relation	DPC (male-female)	*p-value*	DPC (public-private)	*p-value*
H1	Ce → Cr	-0.094	0.116	-0.130	0.248
H2	Ce → Sc	-0.029	0.833	-0.041	0.842
H3	Df → Cr	0.058	0.681	-0.258	0.248
H4	Df → Sc	0.074	0.202	0.048	0.684
H5	Cr → Sc	-0.017	0.881	0.323	0.145

Note. DPC = Difference of Path Coefficient.

Table 4 presents the relationships between the proposed dimensions, in which we found that of the 5 proposed relationships, 3 were statistically significant, showing that digital fluency and continuing education do not influence professors' scientificity. The model presented coefficients of explanation $R^2 = 0.406$ ($p = 0.000$) for Creativity and $R^2 = 0.079$ (p = 0.001) for scientificity.

Table 4. Results of the analysis of structural coefficients

Hypotheses	Path relation	Coefficient	sd	t stat.	*p-value*	Result
H1	Ce → Cr	0.466	0.041	11.412	0.000	Supported
H2	Ce → Sc	0.013	0.063	0.210	0.834	Not supported
H3	Df → Cr	0.262	0.049	5.371	0.000	Supported
H4	Df → Sc	0.080	0.060	1.336	0.182	Not supported
H5	Cr → Sc	0.223	0.064	3.483	0.001	Supported

Note. sd = standard deviation.

4.3 Levels of Competencies in the Researched Teaching and Innovative Work

The mean standard scores of the STW-ICE Scale and its dimensions are presented in Table 5 and the comparison between the groups is in Table 6. We observed that the dimension with the highest intensity is Continuing Education (85.09 ± 11.368), classified as high, while the dimension with the lowest intensity is scientificity (63.86 ± 22.944), classified as moderate. Initially, to compare the groups of professors, the normality of the standard scores was tested using the Shapiro-Wilk test, and we obtained a non-significant value for normality ($p < 0.05$); hence, we opted to use the Mann-Whitney test. Comparing the scales in general between genders and types of institutions showed no difference between the professors ($p > 0.05$). However, when comparing the dimensions between genders, we observed that men have more continuing education and greater creativity than women ($p < 0.05$). Comparing the type of institution showed that professors from private institutions have greater digital fluency and continuing education, while those from public institutions have greater creativity and

scientificity ($p < 0.05$).

Table 5. Descriptive statistics of standardized scores (Ss_i) for the STW-ICE Scale.

Scale/dimension	Mean	Standard deviation	Cronbach's alpha
STW-ICE	71.91 (H)	12.399	0.887
Digital fluency	71.94 (H)	14.947	0.764
Continuing education	85.09 (H)	11.368	0.791
Creativity	71.59 (H)	14.648	0.803
Scientificity	63.86 (M)	22.944	0.917

Note. H = High, M = Moderate.

Table 6. Comparative analysis of standardized scores (Ss_i) between groups.

Scale/dimension	Male (n = 261)		Female (n = 261)		*p-value**
	Mean	sd	Mean	sd	
STW-ICE	72.93 (H)	12.466	70.90 (H)	12.249	0.075
Digital fluency	72.13 (H)	14.277	71.75 (H)	15.587	0.768
Continuing education	87.18 (H)	10.168	83.01 (H)	12.095	0.000
Creativity	73.44 (H)	14.617	63.79 (M)	22.117	0.002
Scientificity	63.93 (M)	23.738	70.90 (H)	12.249	0.777
	Public (n = 463)		Private (n = 54)		*p-value**
STW-ICE	72.22 (H)	12.389	69.32 (H)	12.178	0.130
Digital fluency	84.74 (H)	11.214	88.12 (H)	12.198	0.002
Continuing education	71.26 (H)	15.124	77.91 (H)	11.718	0.001
Creativity	71.21 (H)	14.887	50.43 (M)	21.768	0.037
Scientificity	72.22 (H)	12.389	69.32 (H)	12.178	0.000

Note. sd = standard deviation, H = High, M = Moderate. *Mann-Whitney Test.

5. Discussion

Our findings show the proposed scale has structural validity and invariance between groups. This means the scale can measure the proposed dimensions according to the indicators developed and tested in different groups. These groups were evaluated two by two, including gender and types of institutions, without changing the scale's measurement behavior.

The dimension of continuing education is essential in assessing professors' lifelong learning process and professional development. It helps keep them updated with emerging educational trends and practices (Curran et al., 2019; Potyrała & Tomczyk, 2021). Creativity measures the ability to generate new ideas, approaches, and solutions and encourage curiosity and experimentation in the learning process (Shubina & Kulakli, 2019; Huang et al., 2022). This promotes the development of 21st-century skills in problem-solving and adaptability (Mutohhari et al., 2021).

Digital fluency refers to professors' ability to effectively integrate and use digital technology and social media in their teaching practices. It also promotes digital literacy and citizenship among students (Curran et al., 2019; Erwin & Mohammed, 2022). Finally, scientificity refers to professors' ability to apply scientific principles, evidence-based research, and analytical approaches to their teaching practices (Devechi et al., 2022). It is linked to critically evaluating information, developing hypotheses, conducting research, and applying the results to continuously improve educational practices (Ploj Virtič, 2022).

Upon subjective evaluation of the dimensions of the scale, we found that continuing education is the most relevant dimension (85.09 ± 11.368) in measuring competencies in teaching work. Conversely, scientificity is the least relevant (63.86 ± 22.944). Due to the high demands of universities and certain expectations from professors, Manzanal Martínez et al. (2022) proposed strategies that lead students to reflect and be autonomous in developing critical thinking. However, the Scientificity dimension may be linked to a productivist logic emphasizing the demand for publications. Vieira et al. (2020) identified that graduate program professors felt constrained by this demand to the detriment of other parameters that may better reflect their contribution to teaching, research, and extension activities.

By comparing the dimensions between genders, we observed that men had more continuing education than women ($p < 0.05$), although this finding cannot be generalized. It is necessary to consider some aspects of the

unequal division of domestic activities between genders, which one can consider, for instance, the issue of family responsibility for childcare. This issue may limit women from participating in continuing education courses, which has already been proven, as women published and participated less in research projects during the pandemic than men, and this difference is even greater when one has children (Staniscuaski et al., 2021). This reinforces the need to develop policies and initiatives aimed at promoting gender equality in education and the labor market (Clavero & Galligan, 2021).

Moreover, we identified the same situation regarding creativity, as men were statistically more creative than women. However, just like continuing education, we cannot generalize, and it is essential to promote gender equality by encouraging creativity, working towards inclusive education, and promoting diversified and creative learning environments, as these surroundings are essential to support skill and competency development among students (Munna & Kalam, 2021).

When evaluating the intensities of the dimensions by type of institution, we observed that professors from private institutions have a more expressive and significant digital fluency and continuing education than those from public institutions ($p < 0.05$). This may be because private universities generally have more access to private funding and resources for investing in technology and developing their faculty members, thus allowing their professors to dedicate more time to developing their digital skills and participating in continuing education programs. In fact, a study conducted in Spanish public and private universities on professors' satisfaction regarding the latest administrative and political changes in universities revealed that professors from public universities were more unsatisfied than their peers from private universities; this is likely due to the bureaucratization of the public sector, reinforcing the care that university management must have with such issues that can hinder or delay processes (Olaskoaga-Larrauri et al., 2022).

Lastly, as for creativity and scientificity, professors from public universities presented more expressive values ($p < 0.05$). This may be because professors from Brazilian public institutions mostly have exclusivity contracts, giving them more access to research and development resources, favoring innovation and critical reflection. Therefore, they feel more motivated and supported to develop and apply creative and scientific approaches in their teaching practices.

Hence, the new competencies identified in this study, driven by technological, structural, and contextual changes in the university environment, demonstrate that professors from the public and private sectors have realized the importance of competencies for innovation in teaching, even with minor differences. This is a good indication that new skills, knowledge, and attitudes are being developed in favor of more creative, scientific, and technological education in a constant search for more knowledge. All these points add up to increasing the country's higher education quality.

5.1 Limitations

Contribution to this study is limited to the professors who volunteered during the COVID-19 pandemic, and the sample only includes professors from private and public universities who were willing to respond and contribute to the validation of the scale.

6. Conclusions

This study shows openness to a paradigm shift that encourages professors to reflect on their performance while meeting the demands of the time and space in which they work. It is important to note that although the scale allows for the subjective measurement of teaching competencies for innovation in higher education, the intention is not to create a classification but rather a diagnosis that helps professors and managers develop strategies for innovation and reflection in the triad of teaching, research, and extension that characterizes higher education. Therefore, we expect the scale to bring more attention to the subject and provide opportunities for sharing knowledge and experiences. The dimensions and individual items that compose them can guide discussions and strategies for developing competencies for innovation in higher education professors.

Although the number of respondents was sufficient for validating the scale, we suggest further research with a larger sample and under different circumstances after the COVID-19 pandemic. This will allow for more accurate generalizations about the levels of university professors' competencies. Another limitation is that the scale has only been proposed in Brazilian Portuguese. As an unprecedented scale, we suggest expanding its use to other languages and constructing longitudinal results. In the long term, this can help set trends in higher education.

Acknowledgments

This study was supported by the following Brazilian research agencies: Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) and Fundação de Amparo à Pesquisa do Estado do RS (FAPERGS). We would also like to thank Atlas Assessoria Linguística for language editing.

Authors' contributions

Conceptualization, L.F.D.L., F. V. C., M. G. M., N. K., F. G. L., L. D. T., D. J. C. S, and G. L. M; methodology, L.F.D.L., F. V. C., M. G. M., N. K., D. J. C. S, and G. L. M; software, L.F.D.L.; validation, L.F.D.L. and F. V. C.; formal analysis, L.F.D.L., F. V. C., M. G. M., N. K., F. G. L., L. D. T., D. J. C. S, and G. L. M; investigation, L.F.D.L. and F. V. C.; data curation, L.F.D.L. and F. V. C.; writing—original draft preparation, L.F.D.L., F. V. C., M. G. M., N. K. and D. J. C. S; writing—review and editing, L.F.D.L., F. V. C., F. G. L., L. D. T. and G. L. M; visualization, L.F.D.L. and F. V. C.; supervision, L.F.D.L. All authors have read and agreed to the published version of the manuscript.

Funding

This research received no external funding.

Competing interests

The authors declare that the study was conducted without commercial or financial relationships that could be construed as a potential conflict of interest.

Informed consent

Obtained.

Ethics approval

The Publication Ethics Committee of the Canadian Center of Science and Education.

The journal's policies adhere to the Core Practices established by the Committee on Publication Ethics (COPE).

Provenance and peer review

Not commissioned; externally double-blind peer reviewed.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.

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Appendix A

Below, there are some statements. Please read them carefully and answer according to the frequency that best describes your experience regarding each of them. It is also possible to indicate that they do not apply.

Not applicable	Never	Rarely	Occasionally	Often	Always
0	1	2	3	4	5

Scale of Skills in Teaching Work and Innovation in College Education (STW-ICE)

Dimensions	No.	Questions
Continuing education	1	I seek to learn about new teaching methods
	2	I seek to improve my didactic-pedagogical knowledge
	3	I learn in the classroom through experiences and my relationship with the students
	4	I critically reflect on my teaching practices during planning when I am developing the proposals
	5	I reflect on my teaching practices in a critical way after developing the proposals
Digital fluency	1	I propose activities aimed at the production of different content and materials by students through the use of technologies
	2	I use activities and resources of virtual learning environments (Zoom, Google Meet, Microsoft Teams, for example) in addition to repositories of materials
	3	I diversify the digital technologies I use
	4	I notice an improvement in the quality of teaching and the development of skills because I use technologies
	5	I manage time according to the technology I am using
Creativity	1	I propose original ideas for the institution and/or classroom
	2	I take the risk of proposing new ideas
	3	I create proposals collaboratively with colleagues to develop in the institution and/or classroom
	4	I create proposals collaboratively with students of the institution
	5	I develop various pedagogical strategies for the content
	6	I develop various pedagogical strategies for the evaluations
Scientificity	1	I work as a research professor (in postgraduate courses) at the institution and/or another institution
	2	I develop "Research Projects" with my colleagues and/or mentees
	3	I mentor undergraduate research fellows

4	In my research, I focus on presenting papers at national and/or international scientific events
5	I publish scientific articles in journals
6	I dedicate my scientific activities to crafting scientific reviews for funding agencies and/or scientific journals
7	I submit projects of scientific relevance and innovation to calls for proposals by funding agencies.
8	I am dedicated to being a well-known researcher in both national and international science