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Latent profile analysis of teachers' digital competence at a Brazilian federal university: an application of the DigCompEdu Check-in

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Abstract: This study applied Latent Profile Analysis to 257 faculty members at a Brazilian federal university, aiming to identify empirical profiles of teachers' digital competence based on the DigCompEdu Check-in instrument. The analysis identified three hierarchical profiles: Beginner (28.4%), Integrator (50.6%), and Pioneer (21.0%). The profiles differ in overall proficiency level and

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share a weakness in the Digital Assessment area, even among advanced teachers. The findings offer a transferable analytical model for institutional diagnosis and for continuing education sensitive to faculty heterogeneity.

Keywords: Latent profile analysis; DigCompEdu; Teachers' digital competence.

Análise de perfil latente das competências digitais docentes na Universidade Federal do Rio Grande do Norte: aplicação do DigCompEdu Check-in

Resumo: Este estudo aplicou Análise de Perfil Latente a 257 docentes de uma universidade federal brasileira, com o objetivo de identificar perfis empíricos de competências digitais docentes a partir do instrumento DigCompEdu Check-in. A análise identificou três perfis hierárquicos: Iniciante (28,4%), Integrador (50,6%) e Pioneiro (21,0%). Os perfis distinguem-se em nível geral de proficiência e compartilham fragilidade na área de Avaliação Digital, mesmo entre docentes avançados. Os achados oferecem um modelo analítico transferível para diagnóstico institucional e formação continuada sensível à heterogeneidade do corpo docente.

Palavras-chave: Análise de perfil latente; DigCompedu; Competência digital docente.

Análisis de Perfiles Latentes de la competencia digital docente en una universidad federal brasileña: aplicación del DigCompEdu Check-in

Resumen: Este estudio aplicó Análisis de Perfiles Latentes a 257 docentes de una universidad federal brasileña, con el objetivo de identificar perfiles empíricos de competencia digital docente a partir del instrumento DigCompEdu Check-in. El análisis identificó tres perfiles jerárquicos: Principiante (28,4%), Integrador (50,6%) y Pionero (21,0%). Los perfiles se distinguen en nivel general de competencia y comparten una debilidad en el área de Evaluación Digital, incluso entre docentes avanzados. Los hallazgos ofrecen un modelo analítico transferible para el diagnóstico institucional y la formación continua sensible a la heterogeneidad del profesorado.

Palabras clave: Análisis de perfiles latentes; DigCompEdu; Competencia digital docente.

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1 INTRODUCTION

The COVID-19 pandemic forced a massive and abrupt expansion of technology-mediated education in Brazil, placing the pedagogical quality of digitally supported teaching practices back at the center of institutional debate (Aquino; Zuta; Cao, 2021; Hodges et al., 2020). Brazilian public universities, in particular, simultaneously faced the challenge of maintaining ongoing academic activities and the urgency to enhance remote teaching practices in a context where faculty digital competencies exhibited inequalities across faculty members, thereby becoming an operational condition for institutional continuity (Córdoba Mercado; Rinaldi Portela; Pérez Córdoba, 2025). The post-pandemic period did not diminish this central role; on the contrary, it consolidated the expectation that higher education teaching practices intentionally and pedagogically incorporate digital technologies, increasing the institutional responsibility for the in-service continuing professional development of faculty (Imran et al., 2023).

This new scenario repositioned faculty digital competencies as a relevant object of research. It is no longer merely a matter of evaluating which tools teachers use, but also of understanding how they articulate technology, pedagogy, and domain knowledge into practices that effectively promote learning (Marroni; Carvalho, 2023). International frameworks such as DigCompEdu, developed by the Joint Research Centre (JRC) of the European Commission (Redecker, 2017), offer validated instrumentation for this assessment, organizing teaching competencies into six areas ranging from digital professional engagement to the development of students' own digital competence. In Brazil, the DigCompEdu Check-in instrument was adapted and validated by Lucas and Moreira (2018) and has been applied in national institutional diagnoses (Espírito Santo; Dias-Trindade; Reis, 2022; Marroni; Carvalho, 2023; Teixeira et al., 2024).

Despite the volume of research, a methodological problem persists that limits the institutional impact of these diagnoses: continuing professional development initiatives grounded in aggregated institutional averages tend to operate under an unrealistic assumption of faculty homogeneity. By adopting a unified and hoogeneous training program, the institution risks offering inadequate proposals, insufficient for teachers at initial stages and redundant for those at an advanced level. The result is a waste of resources and low adherence in training initiatives (Bilal; Guraya; Chen, 2019). This mismatch between offered training and real needs constitutes a problem whose resolution depends on institutional diagnoses that respect faculty heterogeneity.

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Most Brazilian studies on faculty digital competencies adopt what methodological literature terms a variable-centered approach: they investigate relationships between variables while assuming relatively homogeneous populations and report institutional averages as the primary characterization of the faculty. In studies utilizing the DigCompEdu framework, this materializes as descriptive analyses presenting means across competence areas, occasionally complemented by correlations between areas and association tests with sociodemographic variables. This approach produces comparable overviews across institutions and contributes to the aggregate mapping of the field (Espírito Santo; Dias-Trindade; Reis, 2022; Marroni; Carvalho, 2023).

There is, however, a theoretical limitation to this approach that has been discussed for decades in international methodological literature. Bergman and Magnusson (1997), in a seminal text, argued that empirical populations are rarely homogeneous and that the methodological operation of treating a heterogeneous population as if it were homogeneous calculating means and estimating relationships between variables under this assumption produces a misleading statistical representation: what can be characterized as the fiction of the average individual, that is, an abstract individual that exists in statistics but rarely in its exact form within empirical reality. Laursen and Hoff (2006) expanded upon this critique by demonstrating that variable-centered approaches can dissolve qualitatively distinct subgroups within a population, omitting precisely the heterogeneity that could guide targeted interventions.

The methodological alternative is the person-centered approach, which operates on the opposite principle: rather than assuming population homogeneity and estimating aggregate parameters, it seeks to empirically identify latent subpopulations that exhibit qualitatively distinct response patterns. Within this tradition, Latent Profile Analysis (LPA) is one of the most widely used techniques (Spurk et al., 2020). Applied to data on teachers' digital competence, LPA can reveal how many latent profiles exist in the investigated population, what the configuration of competencies is within each profile, and how these profiles are distributed across relevant external variables, producing actionable information for designing targeted training policies instead of programs based on averages.

Brazilian literature on faculty digital competencies has contributed significantly to mapping the field, but it remains predominantly anchored in the variable-centered tradition. Recent research in Brazilian federal universities (Espírito Santo; Dias-Trindade; Reis, 2022; Marroni; Carvalho, 2023; Sales; Moreira, 2022) provides valuable institutional diagnoses but operates with means and

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correlations as central analytical instruments, leaving the empirical investigation of internal faculty heterogeneity unexplored. Brazilian studies adopting a person-centered approach to faculty digital competencies remain rare, and no national study, so far as the reviewed recent literature allows us to state, has applied Latent Profile Analysis specifically to the DigCompEdu framework within a Brazilian federal university.

This gap carries analytical and practical costs. Analytically, it misses the opportunity to empirically test whether qualitatively distinct subpopulations exist within Brazilian faculty, or if institutional averages indeed capture the phenomenon adequately. Practically, it loses the ability to provide institutional managers with information granular enough to design differentiated continuing professional development programs. If training initiatives continue to be planned based on average diagnoses, the disconnect between training offerings and real needs persists, compromising the return on institutional investment in faculty development.

This study aims to contribute to addressing this gap through an empirical application of LPA to DigCompEdu Check-in data from a Brazilian public federal university, with a sample of 257 faculty members. The instrument used is validated for Portuguese (Lucas; Moreira, 2018), utilizing a Likert scale ranging from 0 to 4 across the 22 items that comprise the six DigCompEdu areas (Professional Engagement, Digital Resources, Teaching and Learning, Assessment, Empowering Learners, and Facilitating Learners' Digital Competence). The analysis is conducted in the R environment, using the tidyLPA package, and follows the protocol established by Spurk et al. (2020) for determining the number of classes and validating LPA solutions.

The research question guiding this study is as follows: what empirical profiles of faculty digital competencies emerge among faculty at a Brazilian federal university when analyzed through a person-centered approach, and how are these profiles distributed across relevant sociodemographic and disciplinary variables? The overall objective is to identify and characterize these profiles based on self-assessments using the DigCompEdu Check-in instrument. The specific objectives are: (a) to empirically determine the number of latent profiles present in the sample; (b) to characterize each profile regarding its composition across the six competence areas of the DigCompEdu framework; and (c) to examine the distribution of these profiles across relevant sociodemographic and disciplinary variables.

The research contributes on three fronts. The first contribution is that the study empirically presents, within the Brazilian context, a hierarchical tripartite typology of faculty digital competencies

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(Newcomers, Integrators, and Pioneers). This structure echoes recent international studies on digital competencies (Pedersen et al., 2024; Riquelme-Plaza; Marolla-Gajardo, 2026; Rahden; Rubach; Porsch, 2025), suggesting that it may constitute a regularity in the field of higher education teaching competence rather than an institutional peculiarity.

The second contribution is the identification of a shared vulnerability in Digital Assessment, observed across all profiles and even among high-proficiency teachers, a finding that converges with European diagnoses and supports training interventions focused on the pedagogical design of digital assessment. The third contribution is the offering of a transferable analytical model for institutional diagnosis in other Brazilian universities, articulating DigCompEdu as an instrument and Latent Profile Analysis as a technique, aiming toward the development of continuing professional development policies sensitive to faculty heterogeneity.

2 METHODOLOGY

Below, we detail the methodological development of this study.

2.1 Research Design and Approach

This study is a quantitative research project of a descriptive-exploratory nature, utilizing a cross-sectional design and a person-centered approach. This paradigmatic choice responds directly to the formulated research problem, as the hypothesis of faculty heterogeneity assumes the existence of qualitatively distinct subgroups, the identification of which requires specific analytical procedures.

2.2 Participants

The study population comprises 2,413 active faculty members from the investigated university, considering all faculty career tracks within the institution. The final sample consists of 257 faculty members who fully answered the instrument and met the established inclusion criteria.

The sampling strategy was non-probabilistic by convenience. This choice is justified by the characteristics of the population (geographically dispersed across multiple campuses and academic units), the voluntary nature of participation in academic research, and methodological precedents in

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similar studies utilizing DigCompEdu within the Brazilian context (Espírito Santo; Dias-Trindade; Reis, 2022; Marroni; Carvalho, 2023).

The statistical precision of the sample was evaluated using conventional parameters. For the population of 2,413 faculty members, with a 95% confidence level (z-score = 1.96) and a population proportion of 50% (a conservative scenario), the calculated margin of error for the final sample is ±5.8%. It is acknowledged that the sample size falls below the median in the field of LPA research, which, according to the survey by Spurk et al. (2020), is approximately 494 participants. This limitation restricts the complexity of the typological solutions that can be stably identified and was taken into consideration during the phase of selecting the number of profiles.

2.3 Instrument and Data Collection Procedures

The instrument used was the European Portuguese version of the DigCompEdu Check-in (Lucas; Moreira, 2018), adapted for Brazilian Portuguese. The instrument contains 22 items that evaluate faculty digital competencies on a Likert scale ranging from 0 to 4. The 22 items are organized into six competence areas from the DigCompEdu framework (Redecker, 2017): A1 (Professional Engagement, 4 items), A2 (Digital Resources, 3 items), A3 (Teaching and Learning, 4 items), A4 (Assessment, 3 items), A5 (Empowering Learners, 3 items), and A6 (Facilitating Learners' Digital Competence, 5 items). The score for each area corresponds to the sum of the items in that respective area. The psychometric indicators of the instrument, including internal consistency by area and for the full scale, were reported by the authors of the Brazilian adaptation, making it unnecessary to replicate these verifications in the present study.

Data collection took place between December 2024 and May 2025 across two phases (the first from Dec 2024 to Feb 2025, yielding 142 responses; the second from Mar 2025 to May 2025, yielding 128 responses). The instrument was made available on an institutional digital platform in an anonymous format, with an estimated average completion time of 12 minutes. Multichannel dissemination strategies were employed, including institutional emails, institutional social media networks, and internal institutional communication channels.

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2.4 Data Analysis

Data were analyzed using R software, version 4.4.3, within the RStudio environment, version 2026.04.0, utilizing the tidyLPA, mclust, nnet, and tidyverse packages. The analysis followed a four-step structured protocol, in accordance with the recommendations of Spurk et al. (2020) for applying Latent Profile Analysis in empirical studies. The first step consisted of the initial descriptive analysis of the data. Measures of central tendency, dispersion, and shape were calculated for the scores in each of the six DigCompEdu areas to empirically characterize the sample distribution prior to latent modeling.

Following the completion of the descriptive analysis, the study proceeded to the second step, which involved performing an exploratory Latent Profile Analysis. LPA models with solutions ranging from one to five classes were estimated using maximum likelihood estimation via the EM[1] algorithm. The specification featuring equal variances across classes and residual covariances fixed to zero (Model 1 in mclust nomenclature) was adopted as the primary model, constituting the most parsimonious and replicable case. As a sensitivity analysis, a model with free variances across classes (Model 3) was also estimated, allowing for the evaluation of solution stability under more flexible distributional assumptions.

Once the exploratory models were estimated, the third step was the selection of the number of profiles. The choice of k combined statistical criteria and content-based criteria, following the protocol recommended in the literature (Spurk et al., 2020). The evaluated statistical criteria were: Bayesian Information Criterion (BIC) and sample-size-adjusted BIC (ABIC), with lower values indicating better fit; Bootstrap Likelihood Ratio Test (BLRT) with 100 replications, considering a statistical significance of $p < 0.05$ as evidence supporting $k + 1$; entropy, with a minimum acceptable value of 0.70 to ensure satisfactory separation between profiles; and minimum class size, established at $n \geq 25$ or $\geq 5\%$ of the sample (whichever was greater).

Once the typology was established, the fourth step encompassed the subsequent analyses. The study proceeded to characterize the profiles and examine their association with external variables. The classic 3-step approach (Spurk et al., 2020) was adopted, which consists of assigning each participant to the class with the highest modal probability and subsequently treating this assignment as an

[1] Expectation-Maximization (EM). An iterative algorithm developed by Dempster, Laird, and Rubin in their seminal 1977 paper, used to estimate parameters of statistical models when there are latent (unobserved) variables or missing data.

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observed variable in further analyses. It is acknowledged that this approach does not formally correct for classification error. In contexts with adequate entropy (≥ 0.80) and sufficient sample size, literature indicates that the attenuation of effects tends to be modest. When the entropy of the final solution falls within an intermediate range (0.70–0.80), the results of subsequent analyses should be interpreted with corresponding caution.

Subsequent analyses included chi-square tests to examine the association between profile membership and categorical sociodemographic variables (sex, broad area of knowledge), standardized residual analysis to identify which cells contributed significantly to the observed associations, and multinomial logistic regression to examine the joint effect of sociodemographic variables on the probability of profile membership. A statistical significance level of $\alpha = 0.05$ was adopted for all tests.

2.5 Ethical Considerations

The study was conducted in compliance with ethical principles for research involving human participants. In particular, the principles of voluntary participation, informed consent, respondent anonymity, and the exclusive academic use of data were strictly observed.

2.6 AI Usage Declaration

During the preparation of this work, the authors used the Gemini 3 Pro tool, in sessions conducted between April and May 2026, for support in the following stages: (a) review of R language scripts for conducting the Latent Profile Analysis, generating tables, and producing figures; (b) grammatical revision; (c) terminology review; and (d) translation for subsequent reading and verification of international bibliographic references. The empirical data collection, interpretation of findings, final methodological and analytical decisions, as well as the curation of cited sources, were conducted exclusively by the authors. After using the tool, the authors reviewed and edited all content in accordance with the scientific method and assumed full responsibility for the publication's content.

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2.7 Materials Availability

In commitment to open science practices, the supplementary materials for this study are deposited in a public project on the Open Science Framework (OSF), accessible at https://osf.io/z3ahg/overview?view_only=1d4a0ad217184dafb29fbe594c8c0dad. The repository gathers the anonymized dataset, the analysis scripts in R language, as well as the supplementary materials referenced throughout the text: the complete multinomial logistic regression table, the standardized residuals heatmap, and the boxplots showing score distributions by area and profile.

3 RESULTS

Below, we present the results of this study.

3.1 Sample Characterization

The final sample is composed of 257 faculty members from the active staff of the investigated university, a number that corresponds to 10.65% of the institutional population of 2,413 faculty members. The distribution by sex is relatively balanced: 139 female faculty members (54.1%) and 116 male (45.1%); one respondent without sex information was retained in the analysis to preserve the completeness of valid respondents in calculating the latent profiles.

Regarding the major area d of knowledge, the sample is concentrated in Exact and Technological Sciences (86; 33.5%) and Health Sciences (58; 22.6%), followed by Others (50; 19.5%), Humanities (34; 13.2%), Applied Social Sciences (16; 6.2%), and Agricultural Sciences and Related Fields (13; 5.1%); the "Others" category aggregates fields with lower sample representation, such as Linguistics, Letters, and Arts, in accordance with the institutional classification adopted during data collection. Broadly speaking, this composition reflects the institution's disciplinary profile, with a slight underrepresentation of Applied Social Sciences and Agricultural Sciences compared to institutional data reported in previous diagnostics (Marroni; Carvalho, 2023).

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3.2 Identification of Latent Profiles

Latent profile analysis was conducted by estimating models with solutions ranging from one to five classes under two variance specifications: equal variances across classes (Model 1) and free variances across classes (Model 3), following the nomenclature of the mclust package (Scrucca et al., 2016). The selection of the number of profiles was based on the convergence of statistical criteria and content-based criteria, in accordance with the protocol recommended by Spurk et al. (2020). The evaluated statistical criteria included the Bayesian Information Criterion (BIC), the sample-size-adjusted BIC (SABIC), the Bootstrap Likelihood Ratio Test (BLRT), entropy, minimum modal probability, and minimum class size of the smallest class. Content criteria encompassed pedagogical interpretability of the profiles, the presence of qualitative configurational differences, and solution parsimony. Chart 1 below presents the fit indicators for all tested solutions under Model 1.

Chart 1 - Fit indicators of the tested LPA solutions (Model 1, n = 257)

k	LogLik	AIC	BIC	SABIC	Entropia	Prob. modal mín.	n mínimo	BLRT (p)
1	−3920,6	7865,2	7907,8	7869,8	1,000	1,000	257	n.a.
2	−3709,6	7457,2	7524,6	7464,4	0,833	0,953	126	< 0,01
3	**−3631,7**	**7315,3**	**7407,6**	**7325,2**	**0,831**	**0,915**	**54**	**< 0,01**
4	−3597,1	7260,2	7377,3	7272,7	0,831	0,885	37	< 0,01
5	−3570,2	7220,4	7362,4	7235,6	0,841	0,883	23	< 0,01

Source: Prepared by the authors based on estimates from the tidyLPA package (Rosenberg et al., 2018).

Nota: k = número de perfis; LogLik = log-verossimilhança; AIC = Akaike Information Criterion; BIC = Bayesian Information Criterion; SABIC = sample-size-adjusted BIC; n mínimo = tamanho da menor classe; BLRT = Bootstrap Likelihood Ratio Test (k vs. k−1, com 100 replicações). A solução adotada (k = 3) está destacada em negrito.

Inspection of the BIC reveals a characteristic pattern of diminishing returns, with substantial reductions up to $k = 3$ and smaller marginal gains beyond that point. This pattern forms the "elbow" at $k = 3$, which can be visualized in Figure 1. The BLRT is statistically significant across all transitions ($p < 0.01$), which, in isolation, does not allow for discrimination between solutions. Entropy remains above 0.83 from $k = 2$ onward, indicating good separation between classes across all alternatives, whereas the minimum modal probability decreases from $k = 3$ to more complex solutions, signaling a drop in classification quality.

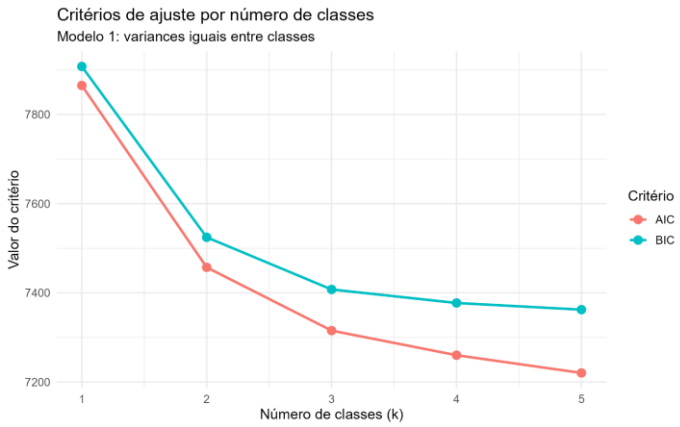
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Figure 1 below graphically illustrates the BIC and AIC curves across the tested solutions, allowing for immediate visualization of the described inflection pattern.

Figure 1 - Fit criteria by number of classes (Model 1, n = 257)



Source: Prepared by the authors based on results from the tidyLPA package (Rosenberg et al., 2018).

Note: BIC (Bayesian Information Criterion) and AIC (Akaike Information Criterion) curves for solutions from one to five classes under the Model 1 specification (equal variances across classes). Lower values indicate better fit. The visually perceptible inflection between $k = 2$ and $k = 3$ corresponds to the BIC "elbow," the point beyond which marginal fit gains become reduced.

The decisive criterion in selecting $k = 3$ involved a combination of three considerations. The first was the minimum size of the smallest class: at $k = 3$, the least represented class groups 54 faculty members, a value well above the a priori threshold of $n_{min} \geq 25$ (Spurk et al., 2020); at $k = 4$ this value drops to 37, and at $k = 5$ to 23, falling below the minimum criterion. The second was the principle of parsimony: the $k = 3$ solution estimates 26 parameters, compared to 33 at $k = 4$ and 40 at $k = 5$, offering a more economical model for marginal fit gain.

The third was the theoretical-pedagogical interpretability of the three classes, which aligns clearly with the DigCompEdu framework, whereas additional classes revealed no qualitatively new configurational patterns. The Model 3 solution (free variances) was evaluated as a sensitivity analysis and produced numerically similar fit criteria; however, $k = 4$ exhibited indicators of instability ($n_{min} = 12$ and minimum modal probability $= 0.755$), reinforcing the selection of Model 1 with $k = 3$.

The convergence of statistical and content-based criteria supports the adoption of the three-profile solution under Model 1, a combination that brings together adequate fit, reliable classification,

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and parsimony. The substantive characterization of these three profiles is presented in the following subsection.

The three-profile solution was named in alignment with the nomenclature of the DigCompEdu framework (Lucas & Moreira, 2018), recognizing that each empirical profile corresponds to a proficiency band composed of two adjacent levels of the framework: the *Iniciante* (Newcomers) profile groups levels A1 (Newcomer) and A2 (Explorer); the *Integrador* (Integrator) profile groups B1 (Integrator) and B2 (Expert); and the *Pioneiro* (Pioneer) profile groups C1 (Leader) and C2 (Pioneer). This correspondence reflects the pattern observed in the empirical centroids of the three classes, as presented in Chart 2 and Figure 2.

Chart 2 presents the estimated model means, with 95% confidence intervals, for each profile across each of the six DigCompEdu areas. The sample sizes and proportions are also reported along with the mean modal probability for each class, an indicator that reflects classification accuracy. All three profiles exhibit a mean modal probability above 0.90, a value considered adequate according to the literature (Spurk et al., 2020). As expected in LPA solutions with neighboring classes, some individual cases present lower modal probabilities, around 0.50, indicating faculty members situated in boundary zones between two profiles. The solution's entropy of 0.831 confirms satisfactory separation between the profiles, meeting the practical criterion of 0.80 frequently cited in applied LPA literature.

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Chart 2 - Centroids of the three latent profiles across each DigCompEdu area ($n = 257$)

Área	Perfil Iniciante (n = 73; 28,4%)	Perfil Integrador (n = 130; 50,6%)	Perfil Pioneiro (n = 54; 21,0%)
	M (IC 95%)	M (IC 95%)	M (IC 95%)
A1: Engajamento Profissional	7,00 (6,42; 7,58)	9,11 (8,68; 9,55)	11,14 (10,49; 11,79)
A2: Recursos Digitais	4,90 (4,42; 5,38)	6,99 (6,62; 7,35)	9,18 (8,64; 9,72)
A3: Ensino e Aprendizagem	5,11 (4,72; 5,49)	9,45 (9,16; 9,74)	13,65 (13,21; 14,09)
A4: Avaliação	3,60 (3,29; 3,90)	5,39 (5,16; 5,62)	8,92 (8,57; 9,26)
A5: Capacitação dos Aprendentes	3,30 (2,93; 3,68)	6,88 (6,60; 7,16)	9,84 (9,42; 10,27)
A6: Promoção da Competência Digital dos Aprendentes	6,43 (5,75; 7,11)	10,34 (9,83; 10,86)	13,43 (12,67; 14,20)
Probabilidade modal média	0,907	0,932	0,917
Probabilidade modal mínima	0,530	0,512	0,506

Source: Prepared by the authors based on estimates from the tidyLPA package (Rosenberg et al., 2018).

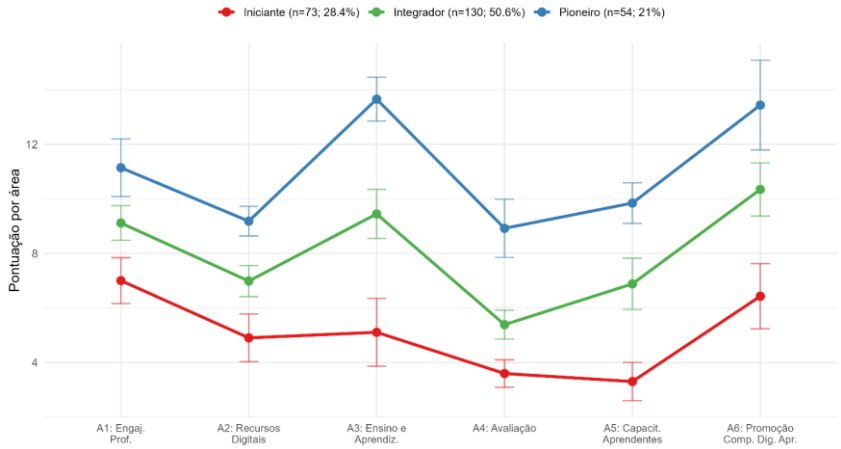
Note: *M* values refer to model-estimated means, with 95% confidence intervals calculated from standard errors. The mean modal probability indicates, for each profile, the average probability with which faculty members assigned to that class belong to it; values above 0.80 indicate reliable classification (Spurk et al., 2020). The minimum modal probability identifies the case with the highest uncertainty in each profile.

The *Iniciante* (Newcomers) profile ($n = 73$; 28.4%) is characterized by consistently low means across all areas, with the lowest values in A4 (Assessment) and A5 (Empowering Learners). This configuration is consistent with faculty members in the early stages of incorporating digital technologies into pedagogical practice, possessing limited mastery of both basic resources and more elaborate digital pedagogical practices. The *Pioneiro* (Pioneer) profile ($n = 54$; 21.0%), at the opposite extreme, displays high means across all areas and corresponds to faculty members who integrate digital technologies comprehensively and sophisticatedly, with high proficiency across all evaluated pedagogical dimensions. The *Integrador* (Integrator) profile ($n = 130$; 50.6%), representing most of the sample, occupies an intermediate position, corresponding to faculty members who already incorporate digital technologies into their practice, but still at an intermediate level of pedagogical elaboration.

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Figure 2 – Latent profiles of teaching competencies ($k = 3$)



Source: Prepared by the authors.

Note: Model-estimated means for each of the three profiles across each DigCompEdu area, with 95% confidence intervals. A1: Professional Engagement; A2: Digital Resources; A3: Teaching and Learning; A4: Assessment; A5: Empowering Learners; A6: Facilitating Learners' Digital Competence.

Visual inspection of Figure 2 allows for the identification of two important characteristics of the solution. The first is that the ordering Pioneer > Integrator > Newcomers remains consistent across all six areas, without line crossings, indicating that the profiles are distinguished by general proficiency level rather than by qualitative configurational differences between dimensions. The second is that the magnitude of distance between profiles varies across areas: areas A3 (Teaching and Learning) and A6 (Facilitating Learners' Digital Competence) discriminate more clearly among the three profiles, whereas areas A2 (Digital Resources) and A4 (Assessment) discriminate less. This differentiation is discussed in greater detail in Subsection 3.3.

3.3 Cross-Cutting Strengths and Weaknesses

Inspection of the centroids in Chart 2 and Figure 2 allows for the identification not only of the hierarchical ordering among profiles but also of a configurational pattern common to all three groups. Although the profiles differ in their overall proficiency level, the profile shape connecting the six areas is similar across groups: the lines run parallel on the graph, without crossings, exhibiting peaks and valleys in the exact same areas. This configurational convergence suggests the existence of an

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institutional signature of relative strengths and weaknesses, common to faculty members at the investigated university, that overlays individual differences in proficiency level.

Three areas consistently function as relative strengths across all profiles. Area A1 (Professional Engagement) displays means above the overall average in every profile. This finding aligns with the type of practice measured by this area: digital institutional communication, participation in professional networks, and continuous professional development are activities widely integrated into daily teaching routines, albeit with varying intensity among faculty. Area A3 (Teaching and Learning) also stands out as a strong point, particularly within the Integrator and Pioneer profiles, indicating that digital pedagogical strategies represent a dimension in which faculty prioritize their investment. Area A6 (Facilitating Learners' Digital Competence) exhibits the highest absolute means across all profiles, reflecting the prevalence within the institutional culture of practices that promote students' critical and responsible technology use.

The study indicates that two areas consistently function as relative weaknesses. Area A4 (Assessment) is the deepest valley in the profile shape across all three groups. In the *Iniciante* (Newcomers) profile, the mean of 3.60 corresponds to level A1 (Newcomer) of the DigCompEdu framework, indicating limited use of digital technologies for assessment purposes. In the *Integrador* (Integrator) profile, the mean of 5.39 still falls within the initial range (A2–Explorer), showing that even intermediate faculty members face difficulties in this dimension. Even in the *Pioneiro* (Pioneer) profile, the mean of 8.92, although higher, places faculty at level B1 (Integrator), below the B2 (Expert) or C1 (Leader) levels that would be expected for faculty members with high overall proficiency in other areas. Area A2 (Digital Resources), while less critical than A4, also ranks among the lower points across all profiles, suggesting that the selection, curation, and protection of digital resources constitute a less developed dimension within the investigated sample.

The magnitude of discrimination across profiles also varies by area. Areas A3 (Teaching and Learning) and A6 (Facilitating Learners' Digital Competence) present the largest differences between the *Iniciante* (Newcomers) and *Pioneiro* (Pioneer) profiles: 8.54 and 7.00 points, respectively. Areas A2 (Digital Resources) and A1 (Professional Engagement) present the smallest: 4.28 and 4.14 points. In other words, the transition from Newcomers to Pioneer is more strongly associated with the development of elaborate digital pedagogical practices (A3) and student empowerment (A6) than with isolated instrumental skills. This pattern is theoretically consistent with the core proposition of the DigCompEdu framework (Redecker, 2017): advanced proficiency levels are distinguished not by the

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simple accumulation of technical domain mastery, but by the ability to articulate digital technologies into student-centered pedagogical practices and students' critical digital education.

The persistence of weakness in Digital Assessment (A4) across all three profiles (a shared vulnerability) constitutes the most institutionally relevant finding of this analysis. Low proficiency in A4 cannot be attributed exclusively to faculty members in the early stages of technology integration, as it is also evident among Integrator and even Pioneer faculty members.

This cross-cutting feature suggests that the difficulty in designing and implementing digital assessments stems less from individual technical limitations and more from structural factors that affect all faculty members equally: a lack of prior training in digital formative assessment, an absence of institutional reference models, and an institutional assessment tradition that remains predominantly analog.

3.4 Demographic and Disciplinary Characterization

The analysis of profile distribution across sociodemographic variables aimed to identify associations between profile membership and faculty characteristics that could guide contextualized training policies. Two variables available from data collection were examined: sex and major area of knowledge.

The relationship between sex and digital proficiency profile, evaluated using Pearson's chi-square test (Chart 3), indicated no statistically significant association ($\chi^2(2) = 2.59; p = .274$). The distribution of the three profiles proves equivalent between female and male faculty members.

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Chart 3 - Profile distribution by sex and standardized residuals ($n = 256$)

Perfil	Feminino	Masculino	Total	Resíduo padronizado (F/ M)
Iniciante	36	37	73	-1,01 / +1,01
Pioneiro	26	27	53	-0,86 / +0,86
Integrador	77	53	130	+1,61 / -1,61
Total	**139**	**117**	**256**	n.a.

Source: Prepared by the authors.

Note: Pearson's chi-square test result: $\chi^2(2) = 2.59; p = .274$. One respondent without sex information was excluded from this specific analysis. Standardized residuals with an absolute value greater than 1.96 indicate a significant contribution of the cell to the association at the $p < .05$ level; no cell reached this criterion.

The relationship between major areas of knowledge and profile was examined in an analogous manner (Chart 4). Pearson's chi-square test produced a value close to the conventional threshold of significance ($\chi^2(10) = 17.58; p = .062$), with a warning that the chi-square approximation may be imprecise due to some cells with reduced expected frequencies (notably Pioneer × Health Sciences, Pioneer × Applied Social Sciences, and Pioneer × Agricultural Sciences and Related, with absolute n between 2 and 5). Although the overall test does not reach the strictly conventional significance threshold, the analysis of standardized residuals reveals consistent patterns in specific cells that warrant detailed reporting.

The cell contributing most to the association pattern is the intersection of the *Iniciante* (Newcomers) profile with Health Sciences, whose standardized residual (+3.15) indicates an overrepresentation of Health Sciences faculty within the Newcomers profile, exceeding the significance threshold at $p < .01$. Symmetrically, the *Pioneiro* (Pioneer) profile exhibits a significant underrepresentation of Health Sciences faculty. The field of Health Sciences thus constitutes the disciplinary axis most strongly associated with profile differentiation.

Other cells with significant or marginal residuals, detailed in Chart 4, include the underrepresentation of faculty from the "Other" field in the Newcomers profile and the overrepresentation of Exact and Technological Sciences in the Pioneer profile.

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Chart 4 - Profile distribution by major area of knowledge and standardized residuals ($n = 257$)

Perfil	Agrárias e Afins	Exatas e Tecnológicas	Humanidades	Outras	Saúde	Sociais Aplicadas	Total
Iniciante	4 (+0,19)	20 (-1,30)	9 (-0,27)	8 (**-2,17**)	26 (**+3,15**)	6 (+0,83)	73
Pioneiro	2 (-0,51)	24 (+1,92)	8 (+0,39)	12 (+0,58)	5 (**-2,63**)	3 (-0,23)	54
Integrador	7 (+0,24)	42 (-0,40)	17 (-0,07)	30 (+1,48)	27 (-0,70)	7 (-0,56)	130
Total	**13**	**86**	**34**	**50**	**58**	**16**	**257**

Source: Prepared by the authors.

Note: Numbers outside parentheses indicate absolute frequencies; numbers inside parentheses indicate Pearson standardized residuals. Chi-square test result: $\chi^2(10) = 17.58; p = .062$. Residuals with an absolute value greater than 1.96 (significance at $p < .05$) are highlighted in bold. The chi-square approximation may be imprecise due to cells with reduced expected frequencies; this aspect is discussed in Section 4. A visual heatmap representation of the residuals is available in the supplementary materials (OSF[2]).

The multinomial logistic regression analysis, conducted while controlling simultaneously for sex and major area of knowledge as predictors of profile membership, detected no statistically significant coefficients at $p < .05$ (all $p > .21$). The wide standard errors, reflected in confidence intervals crossing the odds ratio value of 1, suggest that the sample, especially in cells with lower absolute frequencies, does not allow for the detection of individual effects with adequate statistical power when all variables are evaluated jointly. The complete table of coefficients is available in the supplementary materials (OSF).

In this case, the divergence between the two analyses requires careful interpretation. The chi-square test with standardized residuals detected strong patterns in specific cells, notably the overrepresentation of Health Sciences faculty within the *Iniciante* (Newcomers) Profile. Multinomial regression, by estimating all coefficients simultaneously for a considerable number of combinations between profiles and predictor categories (12 estimated parameters in a sample of 257 faculty members), produces wider standard errors and loses statistical power to detect individual effects.

[2] https://osf.io/z3ahg/overview?view_only=1d4a0ad217184dafb29fbe594c8c0dad

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The fact that the convergent findings from standardized residuals hold up even under a marginally significant global test supports the interpretation that a substantive association exists between disciplinarity and digital proficiency profile, even if this association does not reach strict statistical significance by the most conservative criteria. The pedagogical and theoretical implications of this association are expanded upon in Section 4.

4 DISCUSSION

The findings of this study offer three main contributions, complemented by a specific disciplinary analysis. This section discusses each of them in dialogue with national and international literature on faculty digital competencies, contextualizing them within the field of research and outlining their implications.

4.1 Identification of the Three Profiles, Documentation of Heterogeneity, and Hierarchical Typology

The empirical identification of three hierarchical profiles of faculty digital competencies *Iniciante* (Newcomers, 28.4%), *Integrador* (Integrator, 50.6%), and *Pioneiro* (Pioneer, 21.0%) constitutes the central finding of this study. The predominantly intermediate composition of the investigated sample, with half of the faculty assigned to the Integrator profile, contrasts with the simplified interpretation typically supported by the paradigm of institutional averages.

Previous Brazilian diagnoses based on DigCompEdu, conducted using a variable-centered approach, report institutional averages that place teaching faculties around level B1 (Espírito Santo, Dias-Trindade, & Reis, 2022; Marroni & Carvalho, 2023; Teixeira et al., 2024). Such averages are analytically useful for constructing comparable overviews across institutions, but they dissolve internal heterogeneity and produce what can be characterized as a statistical fiction: the representation of a standard profile that, in practice, rarely exists in its entirety.

The present typology recovers this heterogeneity. The coexistence within the same institution of Newcomers and Pioneer faculty members, proportionally close in volume, is not captured by any mean value. The average of the investigated sample itself would place the teaching body somewhere near level B1, concealing the fact that more than a quarter of the faculty operates at lower proficiency

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levels and that roughly one-fifth operates at substantially higher levels. This heterogeneity serves as useful information for designing institutional policies.

The international convergence regarding the tripartite hierarchical structure of the profiles reinforces the interpretation that this finding is not a peculiarity of the investigated Brazilian sample. Pedersen et al. (2024), in a latent class study with 389 teacher educators across five Norwegian institutions, identified a tripartite typology (Restrictive, Moderate, Extensive) based on strategies for developing professional digital competence. Although the typology by Pedersen et al. operates on a different analytical dimension than ours measuring the frequency and scope of professional learning strategies rather than proficiency levels across framework areas, the recurrence of tripartite structures in latent class analyses applied to the teaching field suggests a pattern that warrants further comparative investigation.

Furthermore, Rahden, Rubach, and Porsch (2025), using LPA applied to German teachers under the DigCompEdu framework, identified three profiles ordered by proficiency level (relatively low / medium / relatively high). In the Ibero-American context, Riquelme-Plaza and Marolla-Gajardo (2026), in a study with 569 Chilean university teachers using the DigCompEdu framework augmented by an Open Education dimension, likewise identified three hierarchical profiles (High, Medium, and Low) with a predominance of teachers at intermediate levels (B1 Integrator). The convergence in a Latin American cultural context, close to the Brazilian one, further strengthens the hypothesis of cross-contextual regularity.

The regularity in the number and shape of the classes, three hierarchical profiles without configurational crossings, suggests that this may be a structural property of the domain of faculty digital competencies in higher education, observable across different national contexts and under different operationalizations of the construct. The transnational regularity of the tripartite hierarchical structure, however, is not a consensus. Studies adopting distinct frameworks or specific analytical scopes identify alternative configurations. Scherer et al. (2021), in a multinational LPA involving 739 university teachers from 58 countries on online teaching readiness, identified three profiles; however, one of them, termed "inconsistent readiness" and comprising approximately 52% of the sample, exhibited a non-purely hierarchical configuration, combining high levels of perceived institutional support with low self-efficacy in TPACK and online presence.

In LPA applied to the integration of mobile technologies among university faculty, Yukhymenko-Lescroart et al. (2021) identified five qualitatively distinct subtypes (Technology

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Enthusiasts, Educated Adopters, Prospective Adopters, Educated Skeptics, and Non-Adopters), demonstrating that finer-grained structures than the tripartite model can emerge when indicators capture attitudinal dimensions beyond proficiency. The tripartite regularity identified in the present study should therefore be interpreted as an observable pattern in specific contexts and operationalizations, rather than a universal structural property of the domain of faculty digital competencies.

4.2 Shared Vulnerability in Digital Assessment

Area A4 (Assessment) stands out as a cross-cutting vulnerability across all three profiles presented. This characteristic is the finding with the greatest institutional implications in the study. In the Newcomers profile, the average score of 3.60 corresponds to level A1 of the DigCompEdu framework, indicating limited use of digital technologies for assessment purposes. In the Integrator profile, the average score of 5.39 still corresponds to the lower band (A2). Even in the Pioneer profile, the average score of 8.92, although higher, remains at level B1, below the B2 or C1 levels that the high overall proficiency in other areas would lead one to expect. The weakness in digital assessment, therefore, cannot be attributed exclusively to faculty in the early stages of technology adoption.

This transversal characteristic converges with international findings. Rahden, Rubach, and Porsch (2025), in a German study with the DigCompEdu framework applied to 698 teachers, recorded that approximately 73% of faculty members are located in profiles in which digital assessment competence is the most fragile, with mid-level teachers feeling especially less capable of using digital tools to monitor learning. The same occurs in the Latin American context, where Riquelme-Plaza and Marolla-Gajardo (2026) likewise identified, among Chilean university teachers, a convergent weakness around Assessment and Feedback, with teachers in the lowest proficiency profile being particularly affected. The regularity of the pattern suggests that the weakness in A4 does not stem from individual technical limitations or specific institutional contexts, but rather from structural factors that affect the field of teacher education on a broader scale.

Three structural factors help explain this shared vulnerability. The first is the systematic absence of prior training in digital formative assessment within the graduate programs that prepare university faculty. Most active faculty members today completed their methodological training during

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periods when technology-assisted assessment was marginal or non-existent, and few opportunities for targeted professional development have been offered by institutions.

The second is the lack of institutional reference models: while digital pedagogical practices have accumulated repertoire in universities, digital assessment practices remain scattered, rarely shared, and often understood as a matter of platform (which tool to use) rather than pedagogical design (how to assess formatively in a digital environment). The third is the institutional assessment tradition, which remains predominantly analog: written summative assessments continue to be the dominant format in most programs, and the digitization of assessment is often limited to converting written exams into online exams, without reconfiguring the instrument's pedagogical function.

The implication of this diagnostic convergence is direct. Institutional continuing professional development programs in educational technologies that focus on tools and platforms, without specifically addressing the pedagogical design of formative digital assessments, perpetuate this vulnerability. Programs that explicitly address A4 by articulating formative assessment concepts, digital feedback strategies, rubric design, and the development of technology-mediated authentic assessments target a key lever for institutional transformation. In this sense, the shared vulnerability is also a shared opportunity: investing in A4 can yield cross-cutting gains across all three profiles, simultaneously benefiting faculty at early and advanced stages of proficiency.

4.3 Disciplinary Divergences and Digital Proficiency: The Case of Health Sciences

The analysis of profile distribution across broad knowledge areas revealed a consistent pattern in which Health Sciences faculty are overrepresented in the Newcomers profile (standardized residual of +3.15) and underrepresented in the Pioneer profile (residual of -2.63). This pattern persisted through complementary analyses: the global chi-square test yielded a value close to the conventional significance threshold ($p = 0.062$), and the multinomial logistic regression did not detect significant individual coefficients due to the wide standard errors resulting from the sample size in certain cells. However, the magnitude of the standardized residuals in Health Sciences × Newcomers and Health Sciences × Pioneer exceeds conventional thresholds ($p < 0.01$), constituting a robust finding in the cell-by-cell analysis that warrants substantive interpretation, albeit with the caution appropriate to fragile inferential convergence.

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The interpretation of the pattern involves factors specific to the disciplinary culture of Health Sciences. The training of healthcare professionals is traditionally anchored in practices with persistent analog elements: face-to-face clinical care, physical examination, and in-person supervision during internships.

Offering digital professional development tailored by disciplinary profile can yield results more closely aligned with faculty-specific needs, particularly for fields like Health Sciences, where the integration between digital practices and applied teaching may require contextualized approaches. Formative strategies that link digital competencies to concrete problems of teaching practice, in partnership with collaborators from the fields themselves, can expand the reach and effectiveness of institutional initiatives. This sensitivity to disciplinary profiles helps translate the identified typology into practical guidance rather than leaving it as a static diagnostic map.

4.4 Implications for Typology-Based Continuing Education Policies

The combination of the three previous findings (configurational heterogeneity of the faculty body, shared vulnerability in A4, and the disciplinary pattern associated with Health Sciences) suggests a transferable analytical model for institutional diagnosis in other Brazilian universities. This model operates through a reproducible methodological sequence: application of the DigCompEdu Check-in, latent profile analysis to identify the specific institutional typology, and cross-tabulation with relevant sociodemographic variables to detect disciplinary or demographic patterns.

The relevance of the model derives from three properties. It is operationally economical, as data collection uses a free and validated instrument (Lucas & Moreira, 2018) and the statistical analysis can be executed in open-source software. It is interpretatively accessible: hierarchical typologies communicate directly with institutional managers without requiring technical familiarity with complex statistical models. It is action-oriented: the typology directly identifies which faculty groups need differentiated training interventions, in which competency areas, and with what priority.

The adoption of the model requires explicit recognition of what it permits and what it does not permit. It permits identifying where institutional weaknesses are concentrated, in terms of both competency areas and specific faculty subgroups. It permits informing the design of differentiated training programs, with distinct pathways for distinct profiles. It does not permit prescribing specific training content or individually predicting which faculty members require intervention. Typology is

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a diagnostic tool, not a substitute for the situated pedagogical analysis that falls to the institution's own teacher educators.

Literature on the person-centered paradigm (Bergman & Magnusson, 1997; Laursen & Hoff, 2006; Spurk et al., 2020) converges on the idea that empirical typologies operationalize what these authors characterize as overcoming the fiction of the average individual. The present research provides a proof of concept, in the Brazilian context, that such overcoming is methodologically feasible and yields actionable information for institutional policies. The continuity of this agenda depends on two complementary fronts: replicated applications in other Brazilian universities to accumulate evidence regarding profile regularity; and longitudinal investigations examining how faculty transition between profiles throughout their professional development trajectories to inform the design of training programs that produce effective progression across levels.

This study applied Latent Profile Analysis at a Brazilian federal university and identified three hierarchical profiles, revealing three main findings that address the objectives set forth in the introduction. The first finding is the empirical documentation of the configurational heterogeneity of the faculty body, masked by the institutional averages paradigm that predominates in Brazilian studies on faculty digital competencies. The tripartite typology that emerged in the present sample echoes recent international studies that identified tripartite structures in latent class analyses applied to the teaching field (Pedersen et al., 2024, with Norwegian teacher educators regarding professional development strategies; Rahden, Rubach, & Porsch, 2025, with German teachers regarding DigCompEdu proficiency; Riquelme-Plaza & Marolla-Gajardo, 2026, with Chilean university teachers under an expanded DigCompEdu framework).

Despite these findings, the observed convergence does not warrant universal generalization: studies adopting distinct frameworks or indicators that go beyond proficiency identify alternative configurations, featuring non-purely hierarchical classes or numbers greater than three. The tripartite structure identified in the present study should therefore be read as an observable pattern in specific contexts and operationalizations, rather than a peculiarity of the investigated sample or a universal structural property of the field.

The second finding is the shared vulnerability around Digital Assessment (A4), observable across all three profiles, including Pioneer faculty, which constitutes the finding with the greatest institutional implications of the study. The regularity of this weakness in Brazilian and international diagnostics supports the interpretation that the issue is structural to the field of teacher education, and

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that overcoming it requires training interventions focused on the pedagogical design of digital assessment, rather than merely acquiring technical mastery of platforms and tools.

The third finding is the disciplinary pattern associated with the major area of Health Sciences, featuring overrepresentation in the Newcomers profile and underrepresentation in the Pioneer profile, suggesting that continuing education policies benefit from sensitivity to the cultures and practices of different areas. Although the inferential confirmation of this pattern was limited by sample size in certain cells, the robustness of the standardized residuals in the cell-by-cell analysis supports substantive interpretation and opens an agenda for future investigations with larger samples and area-stratified sampling strategies.

These three findings, taken together, support the feasibility of a transferable analytical model for institutional diagnosis in other Brazilian universities. The combination of DigCompEdu as an instrument and LPA as an analytical technique is operationally economical, interpretatively accessible to institutional managers, and capable of producing actionable information for the design of profile-differentiated continuing education policies. The identified typology does not replace the situated pedagogical analysis that falls to the institution's own teacher educators but rather offers them a starting diagnostic map for designing training programs that respect the heterogeneity of the faculty body.

The continuation of this research agenda depends on two complementary fronts. Replicated applications in other Brazilian universities can accumulate evidence on the regularity of the identified profiles and contribute to building a national overview of public higher education faculty digital competencies. Longitudinal investigations can examine how faculty transition between profiles throughout their professional development and career trajectories, offering empirical evidence for the design of continuing education programs that result in effective progression across proficiency levels. Complementary qualitative studies can deepen the understanding of the experiences and practices underlying each profile, articulating quantitative results and faculty narratives in a methodological dialogue necessary for the complexity of the investigated phenomenon.

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