

PROFILE OF FIRST-YEAR ENGINEERING AND CHEMISTRY STUDENTS AT UERJ: A DIAGNOSTIC STUDY TO SUPPORT THE PLANNING OF TEACHING, RESEARCH, AND EXTENSION STRATEGIES

PERFIL DOS INGRESSANTES EM ENGENHARIA E QUÍMICA DA UERJ: UM DIAGNÓSTICO PARA O PLANEJAMENTO DE ESTRATÉGIAS DE ENSINO, PESQUISA E EXTENSÃO

PERFIL DE LOS ESTUDIANTES INGRESANTES DE INGENIERÍA Y QUÍMICA DE LA UERJ: UN ESTUDIO DIAGNÓSTICO PARA LA PLANIFICACIÓN DE ESTRATEGIAS DE DOCENCIA, INVESTIGACIÓN Y EXTENSIÓN UNIVERSITARIA

Rayssa Luca Lowndes Pinto da Silva¹, Ester Azedias de Oliveira², Luiza Vieira Peixoto Ferreira³, Lorena Rodrigues Figueiredo⁴, Anne Rodrigues de Lima da Silva Ferreira⁵, Zilacleide da Silva Barros Sousa⁶

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ABSTRACT

This study investigated the socio-educational profile, prior science training, and learning preferences of students enrolled in engineering and chemistry courses at the State University of Rio de Janeiro (UERJ). A quantitative, cross-sectional, and descriptive survey was conducted between August 2025 and June 2026, using a structured online questionnaire administered to 179 students from nine undergraduate programs. Results indicated that 62.6% of respondents attended private secondary schools, while 74.3% reported little or no laboratory experience during high school (never or rarely). A statistically significant association was found between school type and access to practical chemistry activities ($\chi^2 = 11.819$; $df = 1$; $p < 0.001$), indicating that students from public schools had, on average, more frequent laboratory engagement. The most commonly cited difficult chemistry topics were Organic Chemistry and Stoichiometry (both $n = 33$; 18.4%), while the leading causes of difficulty were unattractive teaching materials ($n = 42$; 23.5%) and insufficient practical activities ($n = 36$; 20.1%). Regarding digital learning resources, 96.1% of

¹ Undergraduate student in Chemical Engineering, Universidade do Estado do Rio de Janeiro (UERJ), Rio de Janeiro, Rio de Janeiro, Brazil. E-mail: rayssalowndes@gmail.com

² Undergraduate student in Electrical Engineering, Universidade do Estado do Rio de Janeiro (UERJ), Rio de Janeiro, Rio de Janeiro, Brazil. E-mail: esterazedias@gmail.com

³ Undergraduate student in Civil Engineering, Universidade do Estado do Rio de Janeiro (UERJ), Rio de Janeiro, Rio de Janeiro, Brazil. E-mail: contatorj.luiza@gmail.com

⁴ Undergraduate student in Chemical Engineering, Universidade do Estado do Rio de Janeiro (UERJ), Rio de Janeiro, Rio de Janeiro, Brazil. E-mail: lorf2072@gmail.com

⁵ Undergraduate student in Electrical Engineering, Universidade do Estado do Rio de Janeiro (UERJ), Rio de Janeiro, Rio de Janeiro, Brazil. E-mail: annerlsf2007@gmail.com

⁶ Ph.D. in Chemical Engineering, Universidade do Estado do Rio de Janeiro (UERJ), Rio de Janeiro, Rio de Janeiro, Brazil. E-mail: zila_barros@uerj.br Orcid: <https://orcid.org/0000-0003-0089-2013>

respondents reported using YouTube as their primary academic study channel, and 86.6% indicated a preference for explanatory videos of 5–15 minutes. These findings highlight persistent structural inequalities in pre-university science education, a strong alignment between students' current learning profiles and digital-video modalities, and concrete demands for academic support, particularly in Mathematics and Chemistry leveling.

Keywords: Engineering Education. Chemistry Teaching. Learning Preferences. Socio-Educational Profile. Digital Technologies.

RESUMO

Este estudo investigou o perfil socioeducacional, a formação prévia em ciências e as preferências de aprendizagem dos estudantes matriculados nos cursos de Engenharia e Química da Universidade do Estado do Rio de Janeiro (UERJ). Foi realizado um levantamento quantitativo, transversal e descritivo entre agosto de 2025 e junho de 2026, por meio de questionário estruturado on-line aplicado a 179 estudantes de nove cursos de graduação. Os resultados indicaram que 62,6% dos respondentes cursaram o Ensino Médio em escolas privadas, enquanto 74,3% relataram pouca ou nenhuma experiência em laboratório de Química durante o Ensino Médio (nunca ou raramente). Foi encontrada associação estatisticamente significativa entre o tipo de escola e o acesso a atividades práticas de Química ($\chi^2 = 11,819$; gl = 1; $p < 0,001$), indicando que os estudantes de escolas públicas tiveram, em média, maior frequência de aulas práticas. Os tópicos de Química mais citados como difíceis foram Química Orgânica e Estequiometria (ambos $n = 33$; 18,4%), enquanto as principais causas de dificuldade foram materiais didáticos pouco atrativos ($n = 42$; 23,5%) e insuficiência de atividades práticas ($n = 36$; 20,1%). Em relação aos recursos digitais de aprendizagem, 96,1% dos respondentes afirmaram utilizar o YouTube como principal canal de estudo acadêmico, e 86,6% indicaram preferência por vídeos explicativos de 5 a 15 minutos. Esses resultados evidenciam desigualdades estruturais persistentes na educação científica pré-universitária, forte alinhamento entre o perfil de aprendizagem atual dos estudantes e as modalidades de vídeo digital, e demandas concretas de apoio acadêmico, especialmente em nivelamento de Matemática e Química.

Palavras-chave: Educação em Engenharia. Ensino de Química. Preferências de Aprendizagem. Perfil Socioeducacional. Tecnologias Digitais.

RESUMEN

Este estudio investigó el perfil socioeducativo, la formación previa en ciencias y las preferencias de aprendizaje de los estudiantes matriculados en los cursos de Ingeniería y Química de la Universidad del Estado de Río de Janeiro (UERJ). Se realizó una encuesta cuantitativa, transversal y descriptiva entre agosto de 2025 y junio de 2026, mediante un cuestionario estructurado en línea aplicado a 179 estudiantes de nueve programas de pregrado. Los resultados indicaron que el 62,6% de los encuestados cursaron la educación secundaria en escuelas privadas, mientras que el 74,3% reportó poca o ninguna experiencia en laboratorio de Química durante la educación secundaria (nunca o raramente). Se encontró una asociación estadísticamente significativa entre el tipo de escuela y el acceso a actividades prácticas de Química ($\chi^2 = 11,819$; gl = 1; $p < 0,001$), lo que indica que los estudiantes de escuelas públicas tuvieron, en promedio, una mayor frecuencia de clases prácticas de laboratorio. Los temas de Química identificados con mayor frecuencia como difíciles fueron Química Orgánica y Estequiometría (ambos $n = 33$;

18,4%), mientras que las principales causas de dificultad fueron materiales didácticos poco atractivos ($n = 42$; 23,5%) e insuficiencia de actividades prácticas ($n = 36$; 20,1%). En cuanto a los recursos digitales de aprendizaje, el 96,1% de los encuestados afirmó utilizar YouTube como principal canal de estudio académico, y el 86,6% indicó preferencia por videos explicativos de 5 a 15 minutos. Estos hallazgos destacan las persistentes desigualdades estructurales en la educación científica preuniversitaria, una fuerte alineación entre los perfiles de aprendizaje actuales de los estudiantes y las modalidades de video digital, y demandas concretas de apoyo académico, especialmente en nivelación de Matemáticas y Química.

Palabras clave: Educación en Ingeniería. Enseñanza de Química. Preferencias de Aprendizaje. Perfil Socioeducativo. Tecnologías Digitales.



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INTRODUCTION

The transition from secondary school to higher education in Engineering and STEM programs represents one of the most significant cognitive and social disruptions in the academic trajectories of Brazilian students. The heterogeneity of pre-university educational pathways, marked by inequalities in access to teaching resources, laboratories, extracurricular activities, and scientific stimulation, poses structural challenges for higher education, making an in-depth understanding of the profile of incoming students essential (Gondran *et al.*, 2023; Agostini & Nascimento, 2022).

In Brazil, the expansion of access to higher education promoted by racial and socioeconomic quota policies, ENEM/SISU, and institutional affirmative-action programs has considerably diversified the profile of university students. However, this diversification has not been accompanied by proportional changes in the pedagogical practices of STEM programs, which generally maintain traditional curricula that are insufficiently responsive to gaps in students' basic education (Mendonça & Vieira, 2024; Reis *et al.*, 2020).

Rio de Janeiro State University (UERJ) occupies a unique position in this context: it was the first Brazilian public university to implement a quota system (2003), and its Engineering and Chemistry programs annually receive students from a wide range of educational backgrounds, from elite private schools to public schools in different regions of the state. Understanding how these students enter university, their background in STEM subjects, the difficulties they report from secondary school, and their learning strategies and preferences—is essential for designing

effective and inclusive educational policies.

At the same time, the expansion of digital technologies is reshaping study practices in higher education. YouTube has become a central platform in the autonomous learning repertoire of university students in Brazil and worldwide, providing a low-cost, highly accessible channel with a wide variety of technical content (Nagumo & Teles, 2020; Fragoso, 2020; Rodrigues & Grané, 2023). Understanding whether and how Engineering and Chemistry students use these digital tools is equally relevant to the planning of institutional strategies for science communication and academic support.

Against this background, the general objective of this study was to characterize the socio-educational profile, science background, and learning preferences of students enrolled in Engineering and Chemistry programs at UERJ, based on primary data collected through a structured online questionnaire. Specifically, the study sought to: (a) describe respondents' pre-university educational backgrounds; (b) identify the Chemistry topics considered most difficult in secondary school and the perceived causes of these difficulties; (c) analyze access to digital resources and preferred learning formats; and (d) map students' perceived academic support needs.

THEORETICAL FRAMEWORK

Profile of First-Year Students in STEM Programs in Brazil

Mapping the socio-educational profile of students entering STEM degree programs has become a growing area of research in Brazil. Studies conducted at different public institutions indicate that, despite the diversification promoted by inclusion policies, inequalities in the quality of basic education continue to significantly influence academic performance during the initial semesters of Engineering programs (Gondran *et al.*, 2023; Agostini & Nascimento, 2022).

The study by Reis *et al.* (2020), conducted at the Federal University of Maranhão (UFMA), identified important gaps in basic Chemistry knowledge among students entering the interdisciplinary bachelor's degree in science and technology, demonstrating that the absence of a solid STEM foundation in secondary school represents a risk factor for dropout during the first semesters. Similarly, Mendonça and Vieira (2024) documented high failure rates in university Chemistry courses and proposed leveling courses as a mitigating strategy.

The issue of practical laboratory classes in secondary education is particularly relevant. According to Bulhões and Santana (2022), inadequate laboratory infrastructure in Brazilian schools, compounded by emergency remote teaching during the COVID-19 pandemic (2020–2021), produced cohorts of students whose science education was predominantly theoretical and abstract. Barbosa *et al.* (2025) identified that the main difficulties reported by secondary-school students in learning Chemistry involve a lack of experimental classes, a disconnect between taught content and everyday life, and the excessively technical language used in teaching materials.

Heterogeneity in school background, public versus private, is a relevant structural variable when analyzing the profile of incoming students. Sociological studies show that Brazilian private schools generally provide more tutoring activities, greater pedagogical resources, and stronger integration with university entrance-exam preparation, whereas public technical schools often provide a broader range of practical science experiences, especially federal institutes and university-affiliated schools (Agostini & Nascimento, 2022; Gondran *et al.*, 2023).

Digital Technologies and Learning in Higher Education

The consolidation of digital technologies as mediators of university learning is a globally documented phenomenon. In Brazil, studies conducted over the past decade identify YouTube as the platform most frequently used by higher-education students for academic purposes, far surpassing other social networks and course platforms (Nagumo & Teles, 2020; Fragoso, 2020).

Nagumo and Teles (2020) investigated YouTube use among Brazilian university students and found that the platform is used both as a complement to face-to-face classes and as a primary content source for subjects perceived as insufficiently covered. The authors emphasize that accessibility, free access, and the ability to review content at their own pace are the main factors explaining this preference.

Felcher and Bierhalz (2020) analyzed the role of educational YouTube videos in the initial training of science teachers, demonstrating that video production and consumption contribute to the development of pedagogical skills and meaningful learning of scientific content. Rodrigues and Grané (2023) found that YouTube, Instagram, and podcasts are the channels most frequently used by preservice teachers, with substantial variation according to program and academic semester.

From an international perspective, Greeves and Oz (2024) compared student and instructor perceptions of YouTube use in higher education and concluded that a gap persists between students' preferences, which favor short, dynamic, and informal videos, and instructors' expectations. Tapia-Jara and Sánchez-Ortiz (2020) identified a relationship between learning styles and the intention to use academic YouTube videos, suggesting that students with visual-kinesthetic profiles are more inclined toward video-mediated learning. At the same time, the debate on learning formats indicates that 5- to 15-minute content is more effective than ultra-short formats for complex subjects because it allows more coherent conceptual development (Neuenfeldt & Schuck, 2020; Gomes & Martins, 2021).

Academic Support and Student Retention in Higher Education

The literature on retention and dropout in STEM programs consistently identifies insufficient basic education as a predisposing factor for withdrawal during the first semesters (Stramandinoli, 2025; Melo & Santos, 2024). Mathematics and Chemistry leveling programs, tutoring, and drop-in support sessions are interventions with evidence of effectiveness in reducing failure and dropout rates, particularly when accompanied by strategies that foster student integration into university culture (Mendonça & Vieira, 2024; Silva & Santos, 2019). In this context, systematically mapping the support needs perceived by students themselves is an essential methodological step in designing pedagogically relevant and effective interventions (Agostini & Nascimento, 2022).

METHODOLOGY

Study Design

This was a quantitative, cross-sectional, and descriptive study, with exploratory analysis of associations using chi-square (χ^2) tests of independence. The study was conducted at Rio de Janeiro State University (UERJ), with the target population comprising students regularly enrolled in undergraduate Engineering programs (Electrical, Chemical, Civil, Mechanical, Environmental, Cartographic, Production, and Renewable Energy Engineering) and in Chemistry (Teacher Education Degree).

Instrument and Data Collection

The data-collection instrument consisted of a structured questionnaire developed using Google Forms, comprising 21 objective, multiple-choice, and open-ended questions organized into five thematic sections: (i) program and academic semester identification; (ii) characterization of secondary-school educational background; (iii) experiences with Science/Chemistry in secondary school; (iv) admission pathway and access to digital resources; and (v) expectations and academic support needs.

Data Analysis

Data were analyzed using the Python programming language (version 3.x), with the csv, collections, and scipy.stats libraries. For multiple-choice questions allowing more than one response, absolute and relative frequencies were calculated relative to the total number of respondents. Associations between categorical variables were assessed using Pearson's chi-square (χ^2) test, with a significance level of $\alpha = 0.05$. Tests were applied to associations between: (a) type of secondary school and frequency of practical Chemistry classes; (b) school type and participation in science fairs and Olympiads; and (c) admission through the quota system and frequency of practical Chemistry classes. Analyses involving school type considered the Public and Private categories, excluding students in the mixed category ($n = 9$).

RESULT AND DISCUSSION

Sample Characteristics

A total of 179 students participated in the study, distributed across nine undergraduate programs at UERJ. Table 1 presents the distribution by program. The largest group was enrolled in Electrical Engineering ($n = 60$; 33.6%), followed by Chemical Engineering ($n = 26$; 14.6%), Civil Engineering ($n = 24$; 13.5%), and Mechanical Engineering ($n = 18$; 10.1%). Most respondents were in their first academic semester ($n = 83$; 46.4%), with substantial participation from students in the second through fifth semesters, providing a broad perspective on the early stages of undergraduate education.

Table 1. Distribution of respondents by undergraduate program (n = 178)

Program	n	%
Electrical Engineering	60	33,6
Chemical Engineering	26	14,6
Civil Engineering	24	13,5
Mechanical Engineering	18	10,1
Renewable Energy Engineering	16	9,0
Chemistry (Teacher Education Degree)	11	6,2
Environmental Engineering	9	5,1
Cartographic Engineering	8	4,5
Production Engineering	3	1,7
Other/Not identified	3	1,7
Total	178	100,

Note. Data collected through an online questionnaire (August 2025–June 2026).

Source: Prepared by the authors.

Secondary-School Educational Background

Regarding the type of secondary school attended, 62.6% of respondents (n = 112) reported having studied exclusively at private schools, 31.8% (n = 57) at public schools, and 5.0% (n = 9) in both systems. This profile partly reflects the historical inequality in access to Brazilian higher education. Higher-socioeconomic-status private schools provide more tutoring activities, greater pedagogical resources, and stronger integration with university entrance-exam preparation. Moreover, recent studies indicate that, despite a trend toward reduced inequalities between 2005 and 2015, this democratization of access has stalled since approximately 2015, with significant reductions in financing and scholarship programs (Salata, 2025). The profile observed in this study may indicate persistent limitations in the reach of current quota and inclusion policies, reflecting the elitist legacy that continues to characterize the Brazilian higher-education system (Bertolin, Fioreze & Barão, 2024).

Regarding preparatory courses for university entrance examinations, 60.9% (n = 109) of students reported not having attended any type of preparatory course, 26.8% (n = 48) attended in-person courses, and 11.2% (n = 20) prepared online. Notably, 66.1% of private-school students did not attend any preparatory course, compared with public-school students, among whom 47.4% attended such courses, suggesting that the private-school system partly fulfills the entrance-exam preparation role that, in more vulnerable contexts, requires external preparatory support.

Regarding participation in science fairs, Olympiads, or scientific projects, a notable balance was observed: 50.3% (n = 90) reported participation and 48.6% (n = 87) did not

participate. No statistically significant association was found between school type and participation in Olympiads ($\chi^2 = 0.862$; $df = 1$; $p = 0.353$).

Chemistry and Laboratory Experiences in Secondary School

Access to practical Chemistry laboratory classes during secondary school was markedly limited: 53.1% ($n = 95$) of respondents reported never having had practical Chemistry classes, while 21.2% ($n = 38$) reported only rare access. Overall, 74.3% of students entered higher education with little or no laboratory experience in Chemistry—a concerning finding given the practical requirements of Engineering and Chemistry degree programs.

Table 2. Frequency of practical Chemistry classes in secondary school by school type

School Type	Never + Rarely (n)	Occasionally + Frequently (n)	Total
Public	32	24	56
Private	93	19	112
Total	125	43	168

Note. Analysis restricted to the 168 respondents classified as Public or Private. $\chi^2 = 11.819$; $df = 1$; $p = 0.0006$.
Source: Prepared by the authors.

The chi-square test revealed a statistically significant association between school type and access to practical Chemistry classes ($\chi^2 = 11.819$; $df = 1$; $p = 0.0006$). Students from public schools had a higher proportion of access to practical classes (42.9%) than those from private schools (17.0%). This apparently counterintuitive result may be partly explained by the substantial presence in the sample of students from federal institutes and public technical schools, such as IFRJ, FAETEC, and IFF, which, because of their technical orientation, provide more robust laboratory infrastructure than most academically oriented private schools. Similar results were reported by Agostini and Nascimento (2022), who observed that students from public technical schools showed better initial performance in experimental Chemistry courses.

Regarding the Chemistry topics perceived as most difficult in secondary school, the data show a concentration in two areas: Organic Chemistry ($n = 33$; 18.4%) and Stoichiometry and equation balancing ($n = 33$; 18.4%), followed by Physical Chemistry, kinetics, and equilibrium ($n = 27$; 15.1%), Electrochemistry ($n = 20$; 11.2%), and Solutions ($n = 17$; 9.5%). These findings are consistent with the literature, which identifies these topics as recurrent sources of difficulty in different Brazilian contexts (Barbosa, 2025; Bulhões & Santana, 2022).

The main perceived causes of difficulty were unattractive teaching materials and

instructional approaches (n = 42; 23.5%), insufficient practical and laboratory classes (n = 36; 20.1%), limited connection between content and real-life or Engineering applications (n = 18; 10.1%), and overly technical language (n = 18; 10.1%). The high prevalence of inadequate teaching approaches as a perceived cause of difficulty points to the need to revise Chemistry teaching methodologies in secondary education, including greater contextualization of content through Engineering applications (Bulhões & Santana, 2022).

Admission Pathways and Inclusion

The vast majority of respondents entered UERJ through the State University Entrance Examination (n = 163; 91.1%), while 14 students (7.8%) entered through ENEM/SISU. Regarding the quota system, 12.8% (n = 23) reported admission through this pathway. No significant association was found between quota-system admission and frequency of practical classes ($\chi^2 = 0.013$; df = 1; p = 0.910), indicating that, within the quota-admission group, laboratory experience was distributed similarly to that observed in the overall sample.

Access to Digital Resources and Learning Preferences

Regarding access to devices and connectivity, 87.7% (n = 157) of respondents had a smartphone available for studying, 81.0% (n = 145) had their own laptop or PC, and 79.9% (n = 143) had stable internet access at home. YouTube stood out as the overwhelmingly dominant channel for academic learning: 96.1% (n = 172) of respondents used it, ahead of course platforms (n = 33; 18.4%), podcasts (n = 13; 7.3%), and TikTok (n = 11; 6.1%). This finding strongly corroborates national and international literature (Nagumo & Teles, 2020; Fragoso, 2020; Greeves & Oz, 2024), which identifies YouTube as the leading informal repository of educational content in university settings.

Table 3. Learning channels preferred by students (n = 179; multiple responses allowed)

Learning Channels	n	% (of n=179)
YouTube	172	96,1
Course platforms	33	18,4
Podcasts	13	7,3
TikTok	11	6,1
Instagram	10	5,6

Note. Percentages calculated based on the total number of respondents (n = 179). Multiple responses were allowed.
Source: Prepared by the authors.

Table 4. Learning formats preferred by students (n = 179; multiple responses allowed)

Learning Formats	n	% (of n=179)
Explanatory videos (5–15 min)	155	86,6
Practical/laboratory activities	88	49,2
E-book/step-by-step guide	43	24,0
Short videos (≤ 1 min)	33	18,4
Online classes/Meet	31	17,3
Carousel/infographic	4	2,2

Note. Percentages calculated based on the total number of respondents (n = 179). Multiple responses were allowed.

Source: Prepared by the authors.

Regarding preferred learning formats, explanatory videos lasting 5–15 minutes were selected by 86.6% of respondents (n = 155), followed by practical and laboratory activities (n = 88; 49.2%), e-books and step-by-step guides (n = 43; 24.0%), and short videos of up to 1 minute (n = 33; 18.4%). This finding is consistent with the literature on microvideo learning (Neuenfeldt & Schuck, 2020; Gomes & Martins, 2021) and indicates that ultra-short formats, although popular on entertainment platforms, are not perceived as the most effective for learning complex STEM content. This finding is consistent with Tapia-Jara and Sánchez-Ortiz (2020), who found that university science students tend to prefer videos with an intermediate level of information density, balancing conciseness and conceptual depth.

Academic Support Needs

Regarding the support considered most valuable during the first semester, Mathematics leveling was the most frequently cited option (n = 60; 33.5%), followed by tutoring and drop-in support sessions (n = 34; 19.0%), Chemistry leveling (n = 32; 17.9%), guided study sessions (n = 27; 15.1%), peer mentoring by senior students (n = 10; 5.6%), and introductory practical workshops (n = 10; 5.6%). The predominance of demand for Mathematics leveling is consistent with the central role of Calculus and Linear Algebra in Engineering curricula, whose understanding requires a solid foundation in functions, trigonometry, and analytic geometry, topics that are frequently deficient among incoming students (Gondran *et al.*, 2023).

CONCLUSION

This study characterized the socio-educational profile, science background, and learning preferences of 179 students enrolled in Engineering and Chemistry programs at UERJ, revealing a consistent set of findings with direct implications for the institution's educational management.

The results show that: (a) most incoming students come from private schools but have substantially less Chemistry laboratory experience than their peers from public technical schools, a statistically significant difference ($\chi^2 = 11.819$; $p < 0.001$); (b) Organic Chemistry and Stoichiometry are the topics associated with the greatest reported difficulties, mainly related to unattractive teaching materials and insufficient practical classes; (c) YouTube is used by nearly all respondents (96.1%) as a self-directed study tool, with a strong preference for explanatory videos lasting 5–15 minutes; and (d) Mathematics leveling is perceived as the most important form of support during the first semester, followed by tutoring and Chemistry leveling.

These findings reinforce the urgency of implementing or strengthening institutional leveling, tutoring, and academic integration programs during the initial semesters of Engineering and Chemistry programs at UERJ, as well as investing in the development of digital teaching materials addressing the most critical content areas identified. The adoption of these strategies, grounded in empirical evidence gathered from the students themselves, has the potential to reduce failure and dropout rates while promoting greater equity and quality in higher education.

The study acknowledges its non-probabilistic sampling design and the concentration of respondents in the first academic semester. Future research should expand the sample to include students from more advanced semesters and incorporate objective measures of academic performance to assess associations between the identified profile variables and outcomes throughout undergraduate education.

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