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GENETICS OF HUMAN BEHAVIOR: APPROACHES TO THEORIES IN PSYCHOLOGY AND MITIGATION OF CONTEMPORARY CHALLENGES IN UNIVERSITY TEACHING-LEARNING PROCESSES

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ABSTRACT

This chapter presents the results of activities developed in a teaching internship, linked to the Graduate Program in Food and Health at the Federal University of Minas Gerais, having a direct interface with the discipline of General Genetics. The proposal involved addressing the interactions between genetics of human behavior and environmental factors in the context of university teaching-learning processes. The objective of this study was to reflect

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on genes relevant to cognition, motivation and emotional regulation (Examples: *COMT, BDNF, DRD4 and SLC6A4*), articulating with the fundamentals of educational psychology. The methodology involved theoretical exposition related to self-regulation of learning, mindfulness and positive reinforcement. The subjects were addressed in the second half of 2024 through group dynamics, case studies and the application of a diagnostic questionnaire. The results indicated limitations related to motivation, emotional support and absence of metacognitive strategies on the part of the students. It was concluded that integrative and personalized pedagogical practices, based on interdisciplinary evidence, favor academic well-being and effective learning, were concluded.

Keywords: Higher Education. Active Methodologies. Neuroeducation. Genetic polymorphisms. Educational Psychology.

INTRODUCTION

The study of the genetics of human behavior has emerged as a multidisciplinary field that connects areas such as psychology, neurosciences, and molecular biology, with significant implications for the understanding of cognitive and behavioral processes in educational contexts (Sollero-de-Campos & Winograd, 2009; Camargo, 2020; Santos & Coutinho, 2024). In particular, in the context of higher education, where students are challenged to deal with academic pressures and growing social demands, the integration of knowledge about genetic inheritance and environmental factors becomes essential for the development of more effective and inclusive pedagogical practices (Dal-Farra & Prates, 2004; Feitosa et al., 2021).

Research conducted by Ito & Guzzo (2002), as well as the treatise by Wechsler & Cássia Nakano (2024), argues that behavioral genetics is based on the principle that psychological and behavioral traits, such as temperament, emotional resilience, and cognitive abilities, are influenced by both genetic and environmental factors. Studies of twins, for example, have shown that traits such as academic performance and motivation to learn have a significant hereditary component, but are also influenced by shared and non-shared environments (Baiotto & Silva Loreto, 2018; Siqueira, 2018; Rodrigues et al., 2024). This gene-environment interaction is particularly relevant for university contexts, where factors such as the quality of academic support, financial stress, and interpersonal relationships can modulate gene expression and influence behavior; which results in qualification for learning (Mafra et al., 2018; Pereira, 2024).

In the context of university teaching-learning processes, contemporary challenges include the diversification of student profiles, the increasing prevalence of mental disorders, and the growing dependence on digital technologies, which alter the modes of social interaction and cognition (Guerra et al., 2005; Macêdo, 2018; Castanho, 2024). These changes require innovative approaches that integrate psychological theories and genetic discoveries, aiming to understand and mitigate the effects of such challenges on academic performance. For example, differential susceptibility theory suggests that individuals with high genetic sensitivity may be more responsive to both adverse and enriching contexts, indicating the need for personified educational interventions (Gramz et al., 2016).

Advances in genomic sequencing technologies and big data analysis approaches have enabled a deeper understanding of how genetic variants are associated with specific traits, including learning styles, resilience to stress, and the ability to concentrate (Iriart, 2019). Genes such as COMT, related to dopamine regulation in the prefrontal cortex, have

been associated with cognitive flexibility and the ability to cope with stress (Alves et al., 2024). On the other hand, variants of the DRD4 gene, also involved in dopaminergic signaling, have been correlated with traits of curiosity and novelty-seeking, which directly influence academic motivation (Dreber et al., 2009).

Another prominent gene is BDNF, which encodes brain-derived neurotrophic factor, which is essential for synaptic plasticity and learning. Studies indicate that the Val66Met variant of this gene is associated with individual differences in working memory and associative learning (Santos & Streit, 2014). SLC6A4, the gene that encodes the serotonin transporter, has also received attention for its role in emotional regulation and susceptibility to stress, factors that can significantly influence academic performance in high-demand situations (Solis et al., 2019).

These findings highlight the potential of behavioral genetics to underpin innovative pedagogical practices. Understanding genetic mechanisms and their interactions with the environment can allow the development of personalized educational strategies, such as adaptive teaching methods and support systems focused on specific vulnerabilities of students. For example, mindfulness-based psychoanalytic interventions have shown positive results in stress regulation in individuals with high genetic sensitivity to certain types of tense environments, while gamified teaching approaches can stimulate motivation in students with genotyping associated with exploratory traits (Azevedo & Menezes, 2020).

Nevertheless, numerous psychology techniques offer essential tools to improve the teaching-learning processes, even in the face of limitations imposed by genetic inheritance. Cognitive-behavioral therapy (CBT), for example, has been shown to be effective in modifying dysfunctional thought patterns and strengthening emotional resilience, helping students overcome difficulties related to academic performance (Silva et al., 2024). Emotion regulation techniques, such as mindfulness skills training, can improve the ability to concentrate and reduce the negative effects of stress in high-demand environments, regardless of genetic predisposition (Pellisson & Boruchovitch, 2022).

In addition, strategies based on positive reinforcement, based on Skinner's theory of learning, can be applied to increase motivation and engagement. These approaches are particularly useful for students who have low levels of self-motivation, either due to genetic or environmental influences (Luna, 1999). Another example is the use of socio-emotional interventions, such as promoting empathy and building healthy interpersonal relationships, which can compensate for deficits in skills often associated with genetic predispositions (Machado & Soares, 2024).

Educational psychology also contributes to models based on the self-regulation of learning, such as Zimmerman's approach, which emphasizes the importance of metacognitive strategies and time management. These practices allow students to deal more effectively with academic challenges, creating a bridge between genetic predispositions and the educational environment (Sampaio et al., 2012). Finally, the integration of psychosocial approaches with digital technologies, such as mental health support apps, has the potential to democratize access to emotional and cognitive support tools more quickly, mitigating inequalities arising from genetic and social differences, and several other contextual aspects (Mercurio et al., 2024).

This introduction intended to explore the intersections between the genetics of human behavior and psychological theories, highlighting their applications in mitigating challenges encountered in university teaching-learning processes. The intention was to offer a broad and integrated nod, which initiates a reflection dedicated to education professionals, instigating pedagogical strategies in the light of the most recent scientific discoveries on this theme.

METHODOLOGY

LESSON PLAN - INTERFACE WITH THE GENERAL GENETICS DISCIPLINE (ICA 250) – INSTITUTE OF AGRICULTURAL SCIENCES OF THE FEDERAL UNIVERSITY OF MINAS GERAIS, *MONTES CLAROS* CAMPUS

Theme: "Genetics of Human Behavior: Psychology and Mitigation of Contemporary Challenges in University Teaching-Learning Processes".

GENERAL PURPOSE OF MINISTRY

Introduce concepts of genetics of human behavior and their extensions in university teaching-learning processes.

SPECIFIC OBJECTIVES OF THE MINISTRY

- Present the main genes related to human behavior and its functions.
- Explore gene-environment interaction in the educational context.
- Present psychological principles in the development of pedagogical strategies that can be useful in the performance of daily academic activities.
- Stimulate students' critical thinking to create solutions.
- Demonstrate that the heritability of a trait is often quantitative and strongly influenced by complex environmental factors.

STRUCTURE OF THE TEACHING INTERNSHIP

This teaching internship was based on a robust bibliographic survey on the subject in question, which aimed to subsidize the preparation of a book chapter. These previous surveys, which lasted throughout the second semester of 2024, were preponderant for contact preparation in the classroom. The administration itself took place on 12/17/2024 (Room 05 of Block C, *Montes* Claros Campus of UFMG), for 03 (three) hours (3:00 pm to 6:00 pm).

LESSON STRUCTURE

Part 1: Introduction to the topic (60 minutes)

Initial presentation: "What is behavior genetics?" (Technical aspects in Molecular Biology).

Interactive discussion on the main challenges in teaching and learning.

Brief explanation of relevant genes (*COMT*, *DRD4*, *BDNF*, *SLC6A4*, etc.) and their functions in human behavior (Semensato *et al.*, 2024).

Part 2: Group dynamics (50 minutes)

Case study activities: hypothetical situations of challenges in teaching-learning were analyzed (Example: student with high sensitivity to stress or motivation difficulties).

The students discussed solutions based on psychological theories (CBT, self-regulation of learning, *mindfulness*), as well as foundations on genetic interactions by environments.

Part 3: Application and reflection (50 minutes)

Presentation of possible solutions in line with the students' reflections.

Debate mediated by the teacher and lecturer on the feasibility and impact of the solutions.

Closing with a brief theoretical synthesis.

Part 4: Assessment and quiz (20 minutes)

Delivery of an individual questionnaire adapted from Ribeiro (2012) and final discussion based on the preliminary answers of the students of General Genetics - ICA 250 (sample n = 16).

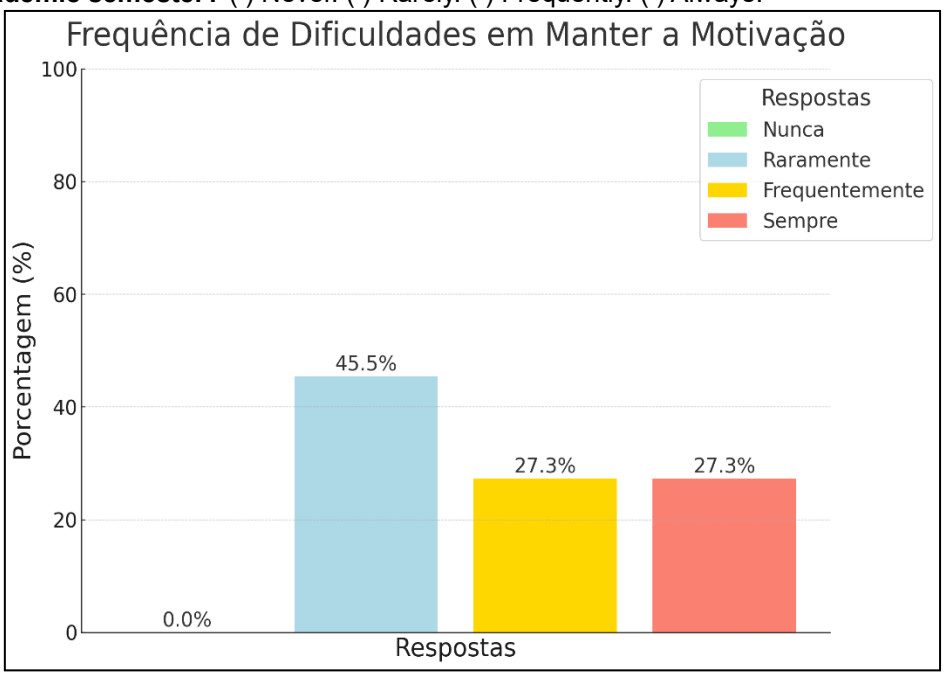
RESULTS

ACADEMIC MOTIVATION: THE RELATIONSHIP WITH ENVIRONMENTAL AND GENETIC FACTORS

The genetics of human behavior emerges as a crucial field to understand the contemporary challenges faced by university students, especially of a psychic nature and academic performance indexes. This area allows us to investigate how genetic predispositions can be overcome, in interaction with environmental and social factors, through psychology techniques that can shape emotions, cognition and behavior. In the reflections of Ganda & Boruchovitch (2018), the integrated analysis of these variables can offer innovative solutions to problems related to motivation, emotional support, self-regulation, and learning limitations.

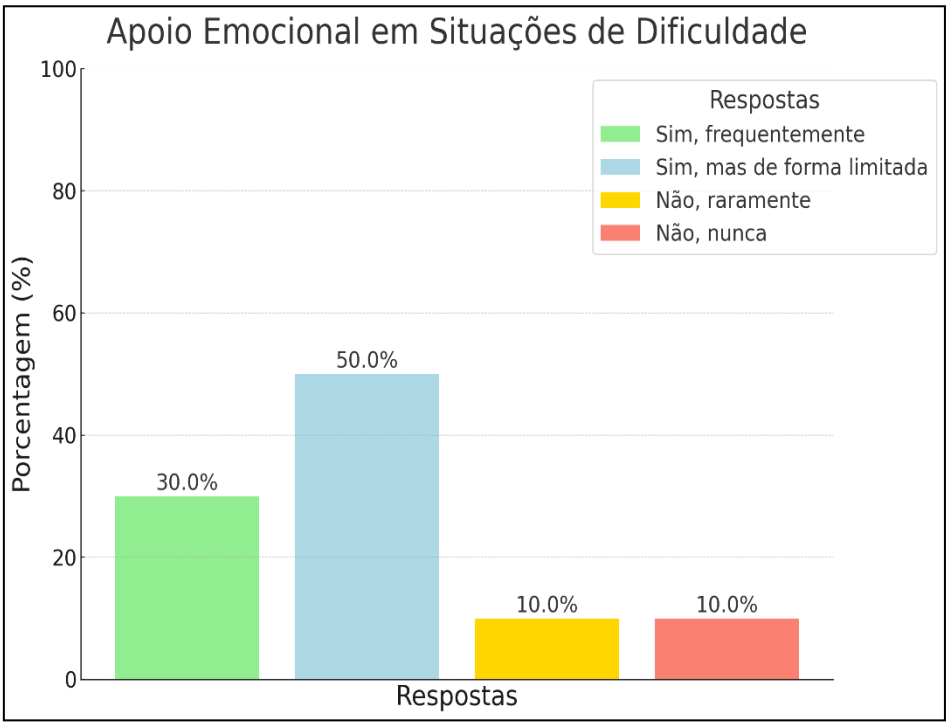
The percentages highlighted in Figure 1 demonstrate that there is a lack of motivation affecting the university students involved in this teaching internship discipline. Personality configuration is undoubtedly influenced by interactions of genetic and environmental factors, as pointed out by recent studies on the genetic basis of dopamine, which in turn is associated with reward and persistence in academic tasks (Abreu Agrela, 2024). On the other hand, other influences are also relevant — students who report difficulties in maintaining motivation may be impacted by deficits in emotional regulation, exacerbated by unwelcoming educational environments, as evidenced in Figure 2.

Figure 1. Objective answers about how often the student faces difficulties in maintaining motivation during the academic semester? ( ) Never. ( ) Rarely. ( ) Frequently. ( ) Always.



Source: Adapted from Ribeiro (2012).

Figure 2. Objective answers about how the student sees himself emotionally supported by colleagues, professors or the institution in difficult situations? ( ) Yes, often. ( ) Yes, but in a limited way. ( ) No, rarely. ( ) No, never.



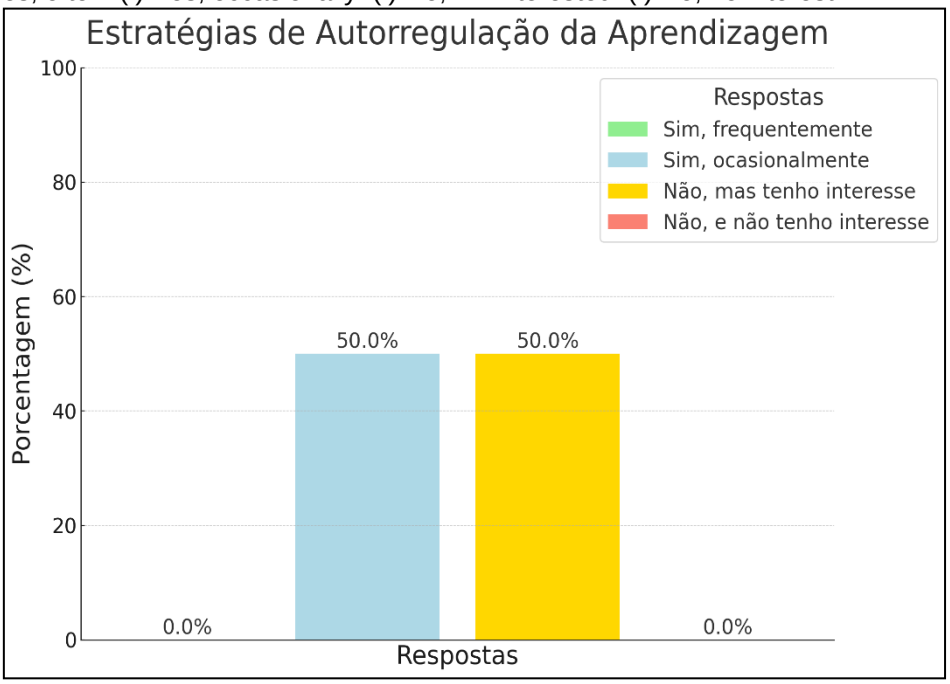
Source: Adapted from Ribeiro (2012).

The lack of emotional support, related by a significant number of students, reflects the lack of institutional policies that promote welcoming and healthy interpersonal relationships. Studies such as those by Guimarães & Boruchovitch (2004) suggest that a positive social environment is essential for intrinsic motivation, which therefore improves knowledge retention. In this context, an integration of pedagogical practices based on positive reinforcement, combined with teacher training in empathy and active listening techniques, can generate substantial benefits.

SELF-REGULATION OF LEARNING: A PATH TO AUTONOMY

Figure 3 reveals that a significant portion of the students do not use self-regulation strategies, even though they show interest in acquiring them. Self-regulation is an essential component of autonomous and effective learning, as pointed out by Andrade Filho et al., (2024), who highlight the role of practices such as planning, monitoring, and self-assessment. This absence of strategies can be partially explained by the lack of specific institutional programs for metacognitive training, something still neglected in many university curricula.

Figure 3. Objective answers about whether you have heard of or applied any learning self-regulation strategy? ( ) Yes, often. ( ) Yes, occasionally. ( ) No, I'm interested. ( ) No, no interest.



Source: Adapted from Ribeiro (2012).

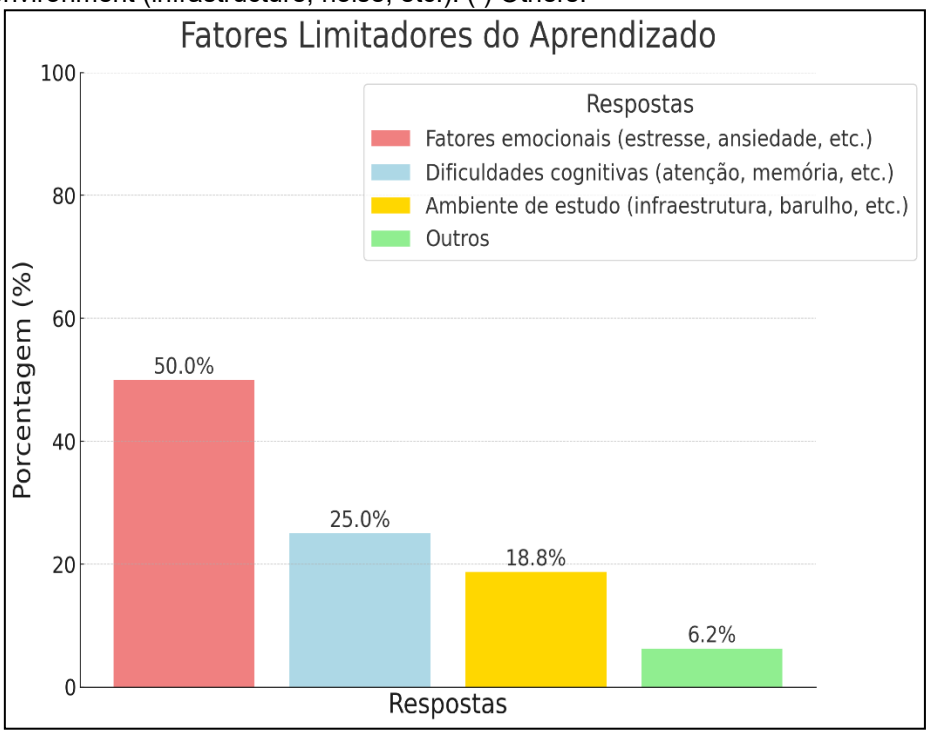
In addition, the responses indicate that a lack of self-regulation is linked to emotional challenges, such as stress and anxiety. The literature suggests that mindfulness-based instruction can be valuable tools to empower students to cope with these challenges, promoting greater mental clarity and academic engagement (Castro & Kestenberg, 2020). Institutions that implement regular self-regulation training modules report significant improvements in academic performance and student well-being.

IMPACT OF LIMITING FACTORS: INTEGRATION OF MULTIDIMENSIONAL SUPPORT

The data in Figure 4 show that emotional factors, such as stress and anxiety, are the main limiting factors of learning, followed by cognitive difficulties and environmental problems. This set of challenges highlights the importance of educational approaches that integrate emotional, psychological, and pedagogical support. Bronfenbrenner's 'Bioecological' Theory (Carvalho-Barreto, 2016) suggests that learning occurs in multiple interconnected systems, being influenced both by the immediate context and by external factors; such as economic difficulties and family demands.

The qualitative analysis of the answers to the "Other" option referred to Figure 4 reinforces this view: the exhausting routine of work and positions, added to university competitiveness, act as factors that feed back anxiety. The lack of institutional policies that take into account the living conditions of students aggravates these issues, pointing to the need for curricular flexibility and continuous psychological support.

Figure 4. Answers about what factors do you believe are the biggest limitations of your learning in the university context? ( ) Emotional factors (stress, anxiety, etc.). ( ) Cognitive difficulties (attention, memory, etc.). ( ) Study environment (infrastructure, noise, etc.). ( ) Others.



Source: Adapted from Ribeiro (2012).

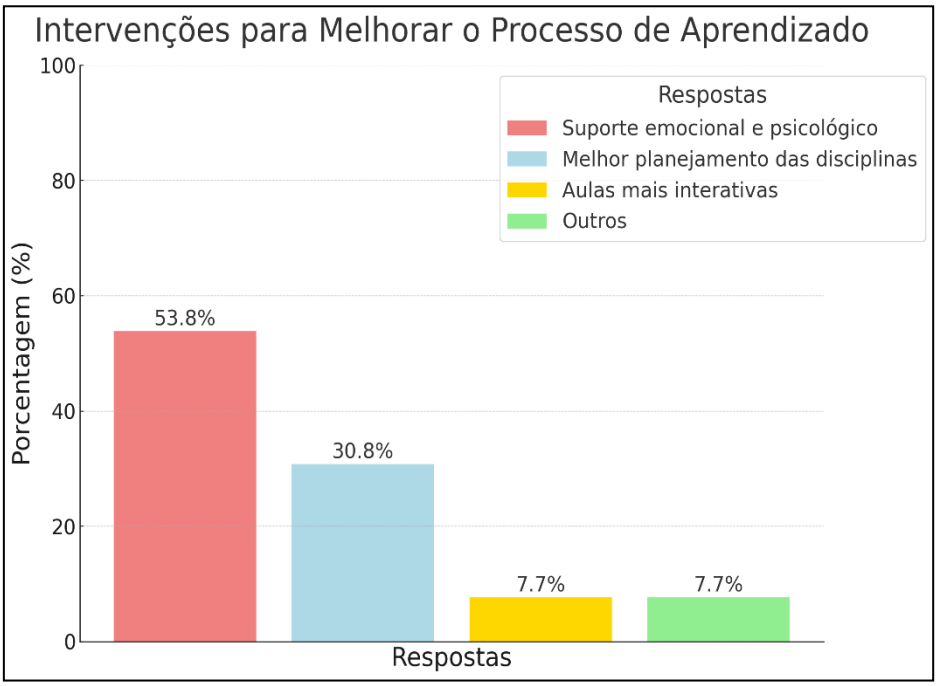
Compilation of comments from the "Other" option, sender to Figure 4:

"The lack of credibility".
"Difficulties of the base prior to university".
"Routine work in other activities such as livelihood and tiring commutes".
"Feedback of anxiety due to the university competitive environment".

INTERVENTIONS AND TECHNOLOGIES: INTEGRATIVE APPROACHES

The theme of interventions and technologies in university education stands out for its ability to approach in a direct and practical way, regarding the gaps identified in emotional, motivational and pedagogical aspects. Figure 5 shows emotional and psychological support as a priority for students, followed by better course planning and more interactive classes. These data reflect the need for integrative strategies that consider the specificities of each student, aligned with the contemporary demands of higher education.

Figure 5. Objective answers about what type of intervention do you believe can improve your learning process? ( ) Emotional and psychological support. ( ) Better planning of the disciplines. ( ) More interactive classes. ( ) Others.



Source: Adapted from Ribeiro (2012).

Compilation of comments from the "Other" option, sender to Figure 5:

"Shorter and more objective classes".
"He can't say what it would be exactly."

Emotional and psychological support emerges as the imperative intervention, highlighting the importance of considering mental well-being as an essential part of learning. The literature points out that the mental health of university students has been increasingly challenged, especially in competitive environments and high academic pressure (Malajovich et al., 2017). Practices such as positive reinforcement are effective tools for addressing these challenges. For example, they have the potential to promote emotional self-regulation, reducing anxiety symptoms and improving focus capacities (Porto Noronha & Viana Batista, 2020).

Nevertheless, regular reception sessions can create an environment of trust between students and teachers, allowing the early identification of signs of psychological distress. According to Vaz (2024), programs that integrate emotional support into the curriculum increase academic retention and performance, while strengthening community ties within institutions.

The second highest priority identified was the most efficient planning of the disciplines. The difficulty of traditional curricula often ignores individual differences in pace and learning style. Studies suggest that flexible models, such as modular curricula and competency-based learning, are more practical in meeting the needs of students (Ciavatta

& Ramos, 2012). In addition, the use of digital technologies, such as learning management platforms, allow for the adjustment of content and schedules, ensuring a more personalized and less stressful experience.

Flexibility should also be continuous regarding aspects of dropouts, as pointed out in the qualitative comments in Question 1. Policies that offer support in times of personal or professional adversity, such as recovery weeks or alternative assessments, can be decisive in improving the academic experience.

Question 1 (open). In your opinion, what aspects of teaching could be adjusted to better meet the individual needs of students? (compilation of the main topics commented):

"Psychological tests and verification of the previous bases necessary for each subject".
"Greater contact and reception of teachers".
"He can't say what it would be exactly."
"Other options for supplementary courses".
"Leaving the student free to make their own choices and develop what, in fact, makes sense to them, which would really add to their previous life to the university (no one deserves to do something just to meet goals)".
"Teachers who show passion for what they do; that try to encourage students to learn more (not just topics in content). I miss that a lot in most subjects."
"Flexibility in relation to absences and certificates. Teachers do not accept it as a justification for absence from their classes."
"Psychological monitoring and mentoring dynamics".
"He can't say what it would be exactly, but he supposes that involvement in research and books would help."
"More practical classes in the area of training".

The answers to Question 1 indicate that more interactive classes are also a priority for students. This data reflects the need to transform traditional teaching methodologies into more active and engaging approaches, such as problem-based learning (PBL) and gamification. Studies indicate that interactive classes promote greater apprehension of content and encourage critical thinking (Moreira et al., 2012).

Concomitantly, educational technologies play a crucial role in this process. Learning apps, such as 'Anki' for space returns or collaborative platforms such as 'Google Workspace', offer tools for dynamic and participatory learning, independent of institutional financial investment capabilities. The comments in Question 2 also point to the use of discussion groups and hands-on activities as valuable resources to increase engagement. This is in line with modern blended learning approaches, which combine face-to-face and virtual moments to maximize educational outcomes (Oliveira et al., 2021).

Question 2 (open). What types of technologies or resources do you think could be used to improve your learning? (compilation of the main topics commented):

"I don't know."
"Discussion groups of the contents (before and after classes)".
"Learning must be pleasurable and be aligned with the student's reality".
"I can't come up with an answer to that right now."
"Concentration and focus techniques, as it is common for me to disperse myself with social networks and other distractions, which leads me to procrastinate and give up on some activities".

"Use of specialized applications could help with revisions."
"Hands on! More practical activities focused on the subject of the various disciplines, so as not to make teaching so boring".

Recent advances in artificial intelligence (AI) bring new possibilities to university education. Adaptive systems, such as 'Smart Sparrow' and 'ALEKS', use Artificial Intelligence (AI) to identify gaps in students' knowledge and offer personalized content in real time. These technologies not only help students progress at their own pace, but also provide teachers with data on the overall performances of the classes under their responsibility, allowing for quick and accurate adjustments in pedagogical planning (Kloeckner et al., 2023).

REFLECTIONS AND FUTURE IMPLICATIONS

The comments in **Question 3** point again to the importance of practices that combine *mindfulness* and positive reinforcement to foster students' confidence and focus. These techniques, by working attention to aspects that are under the control of students at each time frame, help to mitigate the impact of academic and emotional overload (Restrepo *et al*. 2021). The implementation of mentoring based on positive reinforcement, associated with the use of adaptive technologies, can also transform the learning experience.

Future research should investigate the interaction between genetic predispositions and environmental variables in the university context, in order to identify risk profiles and create personalized intervention strategies (Dias *et al*. 2004; Queiroz *et al*., 2011; Arantes, 2023). In addition, longitudinal studies can explore the impact of psychological and pedagogical practices on mental health and academic performance, providing robust data to guide educational policies.

Question 3 (open). Do you believe that the use of psychological techniques, such as *mindfulness* or positive reinforcement, could be effective in university teaching? (compilation of the main topics commented):

"Not as the only approach option".
"Welcoming would contribute a lot. Often, just a simple conversation of support or approval would already bring benefits."
"Yes".
"Yes, because it would bring more confidence to people."
"Without a doubt; the student needs motivation and psychopedagogical support".
"It may be so. It depends on two sides: the university student dedicates himself to this and, in fact, achieves a change in mentality, in addition to psychological mental health".
"Yes, because it helps to deal with the mix of emotions".
"Yes. It helps students with tools to deal with certain situations, which, if not handled, could worsen at critical levels".
"I believe they can help, because sometimes we get discouraged just thinking about the amount of information we need to absorb."
"Yes, because it would move the thoughts of the university students to what is under their control, in order to channel their energies to what is really important at each moment".

DISCUSSION

The questionnaire developed to diagnose the limitations in the teaching-learning process plays a central role in revealing barriers that compromise academic performance. This tool, in addition to mapping emotional, cognitive, and contextual factors that affect learning, allows analyses that support effective psychological and pedagogical interventions. At the frontier of knowledge, current research highlights that well-structured instruments can generate robust data to personalize teaching strategies (Lima David & Dias Chaym, 2019; Ponte et al., 2019).

One of the main psychological aspects revealed by the questionnaire is the influence of emotional factors, such as stress and anxiety, which can compromise students' working memory and attention. These challenges have both genetic and environmental roots. Studies conducted by Semensato et al. (2024) point out that genes such as SLC6A4, associated with serotonin regulation, can influence susceptibility to stress, while psychological techniques such as mindfulness can significantly reduce their effects (Azevedo & Menezes, 2020). Thus, the questionnaire works as a gateway to identify emotional vulnerabilities and propose adapted therapeutic interventions.

From a behavioral point of view, the questionnaire also allows you to assess the impact of intrinsic and extrinsic motivation on learning. Theories such as self-determination highlight that an environment that promotes autonomy, competence, and interpersonal relationships can improve academic engagement (Lopes et al., 2023). Identifying gaps in these aspects, through questionnaires, guides strategies such as positive reinforcement and the use of educational technologies to increase the active participation of students (Marçal et al., 2016).

In addition, by connecting genetic aspects such as those associated with BDNF and DRD4 — which influence synaptic plasticity and exploratory behaviors, respectively — with psychological practices, the questionnaire enables evidence-based interventions (Soares et al., 2019). For example, according to Barroso (2021), students with low resilience can benefit from structured programs for emotional regulation and self-regulation of learning, optimizing their ability to deal with academic demands.

Future prospects include using artificial intelligence to analyze patterns in questionnaire responses, integrating genetic, emotional, and pedagogical data to create personalized learning profiles (Júnior et al., 2023; Souza et al., 2023). This would allow for the implementation of proactive practices, such as training in socio-emotional skills, before difficulties worsen (André et al., 2023). Tools such as psychological support apps could be

developed to provide real-time feedback, transforming the educational experience into a highly adaptive and student-centered journey (Silva Louzada & Souza Pacheco, 2022).

In short, the questionnaire not only aids in the identification of challenges but also acts as a catalyst for the implementation of innovative educational strategies. Its integration with psychological approaches and genetic testing would redefine the potential of higher education (proposing new diagnostic scales that also take into account genetic markers). The central idea is that psychology encompasses auxiliary biotechnological tools, which would certainly optimize approaches with greater accuracy for academic performances.

CONCLUSION

The articulation between the fundamentals of the genetics of human behavior, educational psychology and innovative pedagogical strategies has shown promise for understanding and facing the contemporary challenges of higher education. The reported experience shows that emotional, environmental and genetic factors directly influence academic performance, and it is essential to consider them in the formulation of more responsive and integrative educational practices. The adoption of methodologies focused on the self-regulation of learning, the promotion of emotional well-being, and the use of adaptive technologies can favor the personalization of teaching and increase the effectiveness of pedagogical interventions. Finally, the importance of deepening investigations on the effects of gene-environment interactions in the university context is highlighted, aiming to subsidize institutional policies that combine scientific rigor, psychosocial sensitivity and commitment to educational equity.

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