Gene Therapy and Attitudinal Content in Biological Sciences

Natália Sudan Parducci
nataliasudanparducci@gmail.com
0000-0003-1626-8821
Universidade Presbiteriana Mackenzie, São Paulo, São Paulo, Brasil.

Rosana Dos Santos Jordão
rosana.jordao@gmail.com
0000-0002-2180-031X
Universidade Presbiteriana Mackenzie, São Paulo, São Paulo, Brasil.

ABSTRACT

Gene therapies have gained increasing relevance in recent years, penetrating various social spheres and reaching levels of development never before seen or even imagined. Given their importance, it is essential that this topic be addressed in basic education and, in turn, become a subject of study in teacher training programs. OBJECTIVES: In this context, the present study aimed to analyze the attitudinal content associated with gene therapy among undergraduate students in Biological Sciences teaching programs, investigating the knowledge covered in initial teacher education, its alignment with current educational guidelines, and the overall stance of future teachers on the topic. METHODS: Data were collected through a questionnaire (n = 20) and, in a second stage, through semi-structured interviews (n = 5). RESULTS: The results indicate that 20% of the sample lacked basic conceptual knowledge on the topic and were unable to correctly define the term "gene therapy." Likewise, 55% of the students did not show a willingness to engage in theoretical deepening before making decisions, and 40% of the participants, when asked about attitudinal content, mentioned only conceptual or procedural content. During the interview phase, students showed difficulty in identifying values, were unable to describe the difference between conceptual and attitudinal content, and only two out of the five interviewees addressed the topic from a multidimensional perspective. Among the values identified in the analyzed documents, those most frequently mentioned both in the questionnaire and in the interview phase were: "Concern about the ethical and social implications of gene therapy at both national and global levels"; "encouraging students to take a stance on controversial issues"; and "awareness of the influence of their values and actions as teachers on their students." FINAL CONSIDERATIONS: It was concluded that there is a lack of multidisciplinary treatment of the subject, particularly in the context of its application to human beings, with an emphasis on human rights, cultural diversity, and legislative principles. Thus, the need to move forward in meeting national expectations regarding teacher training, as outlined in guiding documents, is emphasized. It is hoped that the results obtained here can help indicate paths for improvements in future curricular updates.

KEYWORDS: Genetics. Basic education. Initial teacher training.

INTRODUCTION

We are currently witnessing a period of significant advances in the technological and scientific spheres, which converge into a unified field known as biotechnology—now intervening in the very fabric of human nature. Although genetic material has been indirectly modified throughout history by factors such as radiation and pharmaceuticals, it was the consolidation of genetic editing as a field of study that enabled its precise and intentional manipulation, aimed at meeting human needs and aspirations.

At the core of genetic engineering lies a rapidly advancing subdivision: gene therapy. Its definition was well expressed by Linden (2010), who associated it with the introduction of healthy genes—so-called "therapeutic genes"—into an organism through recombinant DNA techniques. In this process, inactive or dysfunctional genes—often responsible for health limitations—are replaced, manipulated, or supplemented (Linden, 2010).

Given this context, it is considered essential that topics related to this emerging and rapidly growing field be introduced in basic education, so that students can critically engage in the heated debates surrounding such advancements. Although the official curriculum guidelines for science education include skills and competencies related to this theme, schools still predominantly focus on what is known as "classical genetics" (Ferreira *et al*., 2017), while attitudinal content related to genetic engineering—and more specifically to gene therapy—remains underexplored and insufficiently assessed (Justina; Rippel, 2003; Lopes, 2023).

The gaps in information and critical engagement concerning this topic are also expanding and infiltrating the basic curriculum of initial teacher education (Xavier; Freire; Moraes, 2005; Gambin, 2022). The rapid pace of biotechnological innovation has hindered the ability to track its consequences in fields such as ethics, morality, and biosafety, resulting in hasty reflections on the limits of therapy—reflections that have yet to reach many schools and universities in Brazil (Ferreira *et al*., 2017).

In this scenario, attitudinal content emerges as an essential element in the preparation and implementation of lessons and explanations that address all dimensions of learning, promoting the development of values, behaviors, and norms.

Based on the foregoing, the general objective of this study is to analyze the attitudinal content related to gene therapy presented by undergraduate students in Biological Sciences teaching programs. The specific objectives are: (I) to identify the attitudinal content taught during initial teacher education; (II) to verify the alignment between such knowledge and the recommendations of state and national documents guiding education and teacher training; and (III) to assess the general stance of future teachers regarding gene therapy.

Building on previous studies in the field of genetic engineering that sought to investigate conceptual and procedural content among preservice teachers (Justina; Rippel, 2003; Xavier; Freire; Moraes, 2005; Ferreira *et al*., 2017), and acknowledging that attitudinal content is more frequently overlooked compared to the aforementioned categories (Zabala, 2015), we assume that the study participants lack principles and values aligned with the requirements set forth by

Page | 2

Brazilian Journal of Science Teaching and Technology, Ponta Grossa, v. 19, p. 1-19, 2026.

national guidelines and that few have reflected on gene therapy from an ethical and moral perspective.

It is hoped that the findings presented here may indicate possible paths for improvements in future curricular updates within teacher education programs. Identifying and mapping both the well-developed aspects and those in need of enhancement will assist in planning and modifying the lessons aimed at preparing individuals for teaching in basic education.

METHODS

The initial stage of this study consisted of a review of national and state documents that guide education and teacher training, namely: the Currículo Paulista (São Paulo, 2019); the Catalog of Syllabi for In-Depth Curricular Studies of the State of São Paulo (São Paulo, 2022); Resolution CNE/CP No. 2/2019, which defines the National Curriculum Guidelines for Initial Teacher Education for Basic Education and establishes the Common National Base for Initial Teacher Education (BNC-Formação) (Brasil, 2019); Resolution CNE/CP No. 1/2020, which sets forth the National Curriculum Guidelines for Continuing Teacher Education for Basic Education and establishes the Common National Base for Continuing Teacher Education (BNC-Formação Continuada) (Brasil, 2020); and the Common National Curriculum Base (Brasil, 2018). Across this set of documents, eight values were identified as being linked to the subject under study and essential to the context of teacher training. These values are summarized in Table 1.

Table 1 – Values related to gene therapy

I. Critical reflection on the scientific discourse used to explain gene therapy in comparison with other types of discourse on the topic (São Paulo, 2019; 2022);
II. Curiosity about understanding the processes involved in the development of new therapies, recognizing their molecular complexity (Brasil, 2018; São Paulo, 2019);
III. Awareness of the importance of prior testing and the involvement of ethics committees in decisions regarding the adoption of new genetic treatments, valuing mechanisms of control over science and corporations (Brasil, 2019);
IV. Appreciation for debate and the plurality of ideas (São Paulo, 2019; Brasil, 2019; 2020);
V. Concern about the ethical and social implications of gene therapy at both national and global levels (São Paulo, 2019; Brasil, 2019; 2020);
VI. Encouragement of students to take a stance on controversial issues (Brasil, 2018; 2019; 2020);
VII. Acknowledgment of the influence of teachers' values and actions on their students (São Paulo, 2019; 2022; Brasil, 2018; 2019; 2020);
VIII. Interest in innovations (Brasil, 2020).

Source: Author's own work (2023).

These values served as the basis for planning the questions that guided the study and for analyzing the data collected (Table 2).

Table 2 – Questionnaire questions

1. What do you know about gene therapy? Have you ever heard about it? If so, briefly explain the topic.
2. Thinking about your undergraduate studies, was there any moment when the topic of gene therapy and its implications was discussed? If so, specify the course in which it occurred and describe the experience.
3. Imagine you were diagnosed with a disease caused by the malfunction of a single gene, and that there is already a gene therapy available for it, although you don't know much about it. Upon consulting a doctor, they advise you to undergo this new therapy. What decision would you make? Justify your answer.
4. Considering the potential harms and benefits of what you understand as gene therapy, how do you perceive the role of ethics and biosafety committees in these advancements?
5. What values would you like your future students to learn regarding the topic of gene therapy?
6. Explain why the values you mentioned in the previous question are truly important.
7. Briefly describe what impact gene therapy might have on the fields of health, politics, economy, and education. If you believe it is not a relevant topic for discussion in one or more of these areas, simply state that you do not find it relevant.

Source: Author's own work (2023).

The sample group consisted of 20 students enrolled in the Biological Sciences Teaching Degree program at a private university in the city of São Paulo. There were no restrictions regarding age, gender, or the stage of the program. Participants were invited via social media, through a promotional message accompanied by a link to access the questionnaire (hosted on Google Forms). The instrument included seven open-ended questions (Table 2), in addition to questions aimed at collecting participants' personal data. It is important to note that the procedures followed the guidelines of the university's Human Research Ethics Committee (Approval No. 1.839.656).

At the end of data collection, the volunteers were assigned identification numbers to reduce selection bias and were referred to as P1, P2, ..., P20. After analyzing the responses, five of them were selected for the semi-structured interview phase (P3, P12, P14, P18, and P20). The criterion for selecting these individuals was their simultaneous fit into the following subcategories (Table 3): possessing technical knowledge about the topic (Category 1), having a systemic perspective (Category 2), and demonstrating curiosity with concern for collective consequences (Category 3).

Table 3 – Analysis categories

Categories	Subcategories	Description
1. Technical knowledge	With knowledge	Was able to define, even if superficially, the concept of gene therapy.
	Lack of knowledge	Was not able to define, even superficially, the concept of gene therapy.
2. Type of perspective	Systemic	Recognized and described the impact of the topic on spheres beyond health and ethics.

Page | 4

Brazilian Journal of Science Teaching and Technology, Ponta Grossa, v. 19, p. 1-19, 2026.

	Non-systemic	Did not recognize or describe the impact of the topic on spheres beyond health and ethics.
3. Attitudes toward real-world issues	Without curiosity	Did not show willingness to engage in theoretical deepening prior to decision-making.
	With curiosity – egocentric focus	Showed willingness to engage in theoretical deepening prior to decision-making, with concern for ethical aspects only at the individual level.
	With curiosity – collective focus	Showed willingness to engage in theoretical deepening prior to decision-making, with concern for ethical aspects at both the individual and collective levels.

Source: Author's own work (2023).

Table 4 – Interview questions asked to the five selected participants

1) Let's begin with a simulation: you started experiencing some unusual symptoms and went to see a doctor. After running some tests, the doctor told you that you have a monogenic disease—that is, a disease caused by a single gene. For this condition, the treatment involves undergoing gene therapy, and you want to learn more about this type of therapy. Can you tell me where and how you would search for information on the topic? Could you describe the step-by-step process?

2) In one of the questions from the first phase of the study, you mentioned that your first contact with the topic was in [...]. Do you remember how the topic was introduced to you? Could you provide more details? (Question customized based on the responses from the first phase of the study)

3) One of the questions in the questionnaire addressed the role of the Ethics Committee in gene therapy research. In that response, you stated [...]. Could you elaborate further on these values? (Question customized based on the responses from the first phase of the study)

4) What is your opinion on genetic manipulation when applied to children?

5) And what about animals?

6) Putting yourself in the role of a Biology teacher and aiming to address both conceptual and attitudinal content with your students, would you be able to differentiate these two types of knowledge?

7) If you had to ask a specialist one question about gene therapy, what would it be? What would you like to know more about?

Source: Author's own work (2023).

The analysis was qualitative, and the categories were developed based on those proposed by Guimarães and Tomazello (2004), Schneider (2015), and Montenegro (2017), adapted to attitudinal content related to gene therapies (Table 3).

RESULTS AND DISCUSSION

As previously stated, one of the main objectives of this study was to identify the attitudinal content taught during initial teacher education. To that end, it was important to assess the participants' technical knowledge, based on the information collected from questions 1 and 2 of the questionnaire. Four participants (P4, P7, P10, and P17) were unable to construct a definition for the

Page | 5

Brazilian Journal of Science Teaching and Technology, Ponta Grossa, v. 19, p. 1-19, 2026.

term gene therapy, collectively stating that they had not come into contact with the topic during their undergraduate studies. The remaining participants mentioned aspects that align with the definition provided by Linden (2010), recalling key concepts such as: "replacing, modifying, or adding inactive or dysfunctional genes" (P6), "altering genes that cause some disease" (P8), "improving living conditions" (P11), and "inserting healthy genes as treatment" (P19).

These responses only superficially addressed the definition, failing to explore how genetic alteration is performed or the living conditions that could be improved through such therapies. There were also inadequate statements such as "cutting out **uninteresting** parts of the DNA" (P8), "forming a more **ideal** gene" (P8), or claims that the technique is only applied in the case of **completely inactive genes** (P15). This reveals the use of terminology not adopted in the fields of genetics and molecular biology, exposing a lack of updated knowledge not only about the topic itself but also regarding basic genetic concepts—a gap already identified by other authors (Rebelo; Mendes; Soares, 2009; Sousa; Almeida, 2017; Ferreira *et al*., 2017).

A total of twelve participants reported having come into contact with the topic during higher education through discussions in courses such as Cell Biology, Histology, Embryology, Microbiology, Bioethics, Genetics, Molecular Biology, Biosafety, Infectious and Parasitic Diseases, and Biotechnology. However, seven of them claimed that the topic was only superficially addressed, and the rest did not provide further details. The four participants who stated in Q1 that they were not familiar with the term gene therapy collectively declared that they had not attended classes in which it was discussed. Thus, the data point to restricted knowledge and a lack of in-depth engagement with the subject.

Continuing with the questionnaire, the second category allowed for the mapping of the type of perspective held by each student, based on their responses to questions 5, 6, and 7. The perspectives were grouped into two subcategories, with 55% of the sample showing a non-systemic view and 45% a systemic one. The uneven distribution—with the non-systemic view being more prevalent—may indicate a lack of familiarity with the details and complexity of gene therapy, including its benefits, risks, ethical concerns, and associated challenges.

An important finding from Q5 was that, although the question asked about the description of values, many responses presented conceptual content instead. This suggests that many students are unfamiliar with the definition of attitudinal content or are unable to identify values and attitudes, reinforcing the conclusions of Sousa and Almeida (2017).

The term "ethics" was mentioned in four answers to Q5, but only P5 specified it as "experimental ethics in research involving humans and animals"; the others merely cited the word. Such generalization of the term may indicate an informational gap concerning ethical contexts—contexts that are crucial for broadening and deepening one's perspective and reflecting on issues in the fields of science, politics, and technology. Each ethical context involves its own nuances and challenges, and the lack of understanding observed here is concerning, as it may hinder the ability to address dilemmas related to the moral frameworks of each field (Smith, 2015).

Still based on the questionnaire, the values identified include: "recognizing the complexity of effects that may result from genetic manipulation" (P1), "appreciating diversity" (P2 and P8), "weighing the pros and cons of new treatments" (P3, P4, P6, P10, P16, P18, and P20), "being aware of the somatic effects [of therapy]" (P4, P10, and P20), "showing empathy" (P12), "respecting the right to freedom" (P13 and P14), "preserving well-being" (P14), and "respecting religious principles" (P20).

When comparing these values to reference documents in the field of education, it is observed that: "protecting genetic variability and, consequently, biological diversity," cited in two responses, is an action provided for in Article 5 of Resolution No. 2/2019; and "being aware of the complexity of its effects and weighing pros and cons" aligns with the goals stated in the BNCC (Brasil, 2018), the Currículo Paulista (São Paulo, 2019), and the Catalog of Syllabi for Curricular Deepening (São Paulo, 2022), which affirm that the aim of education is to develop critical thinking and curiosity about the processes involved.

When asked about the importance of these values in the classroom (Q6), 15 participants implicitly expressed concern for the critical positioning of their future students through statements such as: "so they can develop their own views on the subject" (P3), "to be truthful about the pros and cons of the procedures" (P6), "to exercise critical thinking" (P13), "to form conscious, ethical, responsible, and sensitive citizens" (P14), and "to spark discussion and stimulate the critical thinking of each student" (P20). A certain alignment can be observed with some of the guidelines from the BNCC (BRASIL, 2018), the Currículo Paulista (São Paulo, 2019), and the Catalog of Syllabi for Curricular Deepening (São Paulo, 2022), although gaps remain regarding other general competencies, such as the practice of empathy and a sense of community.

Finally, question 7 addressed the concern of student teachers with the ethical and social implications of gene therapy. Only seven of them described its social relevance in the spheres of health, politics, economy, and education. Those who did referred to the following points: (I) the development of treatments in the field of health; (II) ensuring the availability of treatments through legislative updates in politics; (III) research funding and control of profit-cost relations by the economy; and (IV) the approach to conceptual and attitudinal content in education. Despite the lack of detail, the other thirteen participants also reaffirmed the importance of the topic in each of these areas.

Recognizing the relevance of the topic is significant in terms of mapping individuals' depth of knowledge and their ability to adopt diverse perspectives. As also explored in Q1, the level of technical knowledge influences, according to Zabala (2015), the effectiveness in making choices that promote the exercise of critical awareness and responsibility, being essential in the process of selecting the values to be followed. The difficulties in defining values (Q5), identifying their importance (Q6), and viewing the object of study from multiple dimensions (Q7) reveal a significant gap in the teaching and learning of attitudinal content related to the topic, despite 80% of the sample being able to define the term "gene therapy."

Regarding the behavior participants would adopt in the face of real-life problems, 55% did not demonstrate curiosity toward a deeper understanding of the processes involved in Q3. The decision to adopt or not gene therapy was based

on: cost (P1), side effects (P2 and P6), benefits to quality of life (P4 and P9), and the opinion of a doctor (P5, P7, P8, P10, P11, and P19). The data obtained contrast with the results of Schneider, Meglhioratti, and Corazza (2016), with a general tendency here to highlight the positive aspects of the technique, in opposition to the negative aspects mentioned by the authors. One justification for this discrepancy could be the age difference of the samples, allowing the hypothesis that the student teachers, graduating during the rise of genetic engineering, may be more receptive to it and value its use in disease treatment.

Although most participants presented an optimistic perspective, some responses highlighted concerns regarding the resurgence of eugenic ideas (P20) and the application of such procedures on individuals lacking agency, such as children and animals (P12). Even though the future legal status of restrictions on this type of therapy remains uncertain, the current strand of eugenics differs from that mentioned by participants, as it is rooted in individual choices, respects the value of autonomy, and frames such genetic interventions as private consumer goods (Sandel, 2015), rendering comparisons with past eugenic movements inadequate. In this context, participants recognized the importance of Ethics Committees, but not all of them clarified their role or were able to explain in more detail why they are important, which is inconsistent with the implicit values in the Currículo Paulista (São Paulo, 2019) and in the CNE/CP Resolutions No. 1 of 2020 (Brasil, 2020) and No. 2 of 2019 (Brasil, 2019) — such as values III and V.

Concluding the first phase of the research (online questionnaire), the responses obtained here aligned with those of Xavier, Freire, and Moraes (2005). Although a large portion of participants seemed open to the use of gene therapies, 20% lacked basic conceptual knowledge on the topic and were unable to define the term "gene therapy" correctly. Likewise, 55% did not show a willingness to pursue theoretical deepening before making decisions, and 40% of the sample, when questioned about attitudinal content, were only able to cite conceptual or procedural content.

In the second phase of the study, the five interview participants (P3, P12, P14, P18, and P20), although they demonstrated greater theoretical knowledge on attitudinal content related to gene therapies in the questionnaire, faced difficulties when asked to name values they considered essential for the appropriate use of these therapies. Among the responses were: the right to autonomy to choose whether or not to undergo treatment, related to the idea of ensuring accessibility (P3, P18); freedom of decision (P3, P18); ensuring the patient's health (P3); respect for the diversity of opinions, including religious perspectives (P3, P20); preservation of public safety (P12); empathy for those with diseases (P14); and respect for human integrity (P14) and for bioethical standards (P3, P12, P14, P18, and P20).

The interviewees did not elaborate on definitions of values. P14 clearly stated that they considered attitudinal content to be very abstract, a point previously supported by Pozo and Crespo (2009), who explain the nature of values as fluid, dynamic, and broad. P3, P14, and P20 justified that part of their difficulty in defining values stemmed from limited conceptual and procedural knowledge of the techniques, a finding also highlighted by other researchers (Fávaro *et al.*, 2003; Schneider; Meglhioratti; Corazza, 2016). This result aligns with Zabala's (2015) observations regarding the limited attention given to attitudinal content in teacher education programs. In contrast, P12 and P18 reported a personal interest in the

Page | 8

Brazilian Journal of Science Teaching and Technology, Ponta Grossa, v. 19, p. 1-19, 2026.

area and were the only participants who developed multidimensional reflections on the implications of the advances discussed, citing cases exemplifying ethical and legislative challenges.

Regarding their first encounters with the topic of gene therapy, P3 was the only one who had initial contact during basic education; P12, P14, and P18 reported learning about it in college, while P20 mentioned their experience as an intern in a non-formal education setting. These findings are consistent with those of Domingues *et al*. (2003).

The brief mentions of gene therapy noted by the participants during their teacher training reinforce the findings of Fávaro *et al*. (2003) and Ferreira *et al*. (2017), emphasizing that the topic is often fragmented and included only occasionally in specific course moments. It is important to note that the limited coverage of the subject in college does not stem solely from outdated faculty or a lack of interest among students and professors; the limited class time, as noted by P18, and the complexity of the topic, mentioned by P14, are additional challenges also discussed in the literature (Ribeiro, 2006).

It was found that knowledge gaps were related to two of the pillars identified by Fávaro *et al*. (2003): currently applied techniques and ethics and legislation. Regarding techniques and the value "interest in novelty" (Brasil, 2020), the interviewees stated that they had only limited knowledge. Their main curiosities included: (I) the career paths of professionals working in the field; (II) how to balance culture, health, and ethics; (III) what stage of development we are currently at; (IV) which diseases can already be treated with gene therapy; (V) what its consequences are; (VI) which points a healthcare professional believes should be discussed with the public; (VII) why so much research is being carried out; and (VIII) whether scientists see purpose in their work. Further details related to ethical procedures were also cited as a topic lacking in-depth discussion.

In the realm of ethics, the interviewees' statements revealed inaccuracies and a generalized use of the word "ethics", as in: "to ensure that [the research] follows the ethical standards we live by" (P3); "It [a community meeting] brings each person's perspective, [...] everyone's codes of ethics" (P12); "So, I imagine there must be a Committee to check whether the research is being conducted ethically" (P14); "[...] but there are more ethical ways to do it, right?" (P14). The data reinforces the limited knowledge of the specific branches of ethics, as summarized by Smith (2015), a division that is relevant when analyzing and weighing values in each context. Without an understanding of these different areas, forming a multidimensional perspective becomes difficult, and obligations and dilemmas tend to be generalized.

Regarding the use of gene therapy in children and animals, only two out of the five interviewees were able to contribute to the debate. As for children, all interviewees described the subject as highly complex. As a reason for not having a formed opinion, P3 stated: "Obviously, I'm not a mother, and I don't know how that… I think maybe the circumstances would be different in my head if I were a mother versus today." The positions converged in supporting the use of therapies as treatment in cases of high lethality, with P12 setting the age at which a child should be able to decide for themselves at 10 years old, and P18, at 14. Decisions made by guardians would be guided by medical opinion (P3), assisted by well-conducted and personalized research, avoiding interference from fake news (P18).

The importance of maintaining transparency with children regarding the diseases, treatments, procedures, and their possible consequences was also emphasized (P20), thus safeguarding, to some extent, their autonomy—a value highlighted by Goldim (2015) in a similar context.

When the focus of gene therapy shifted from children to animals, uncertainties prevailed. In the context of scientific research, therapeutic genetic manipulation was seen as inevitable, though capable of improvement through the development of alternative in vivo testing models and ensuring good living conditions for the animals used. In the case of pets, the need for a careful assessment of the pros and cons was raised, given their already short life expectancy and the potential benefits of the therapy. A difference in perspectives between the use of therapy in animals and in children was observed, a difference already foreseen by the Ethics Committees themselves (Delmas-Marty, 2010).

All reflections developed so far align with national policy recommendations and, most importantly, uphold the basic human right to freedom, directly linked to personal autonomy. The potential irreversibility of medical procedures and the possibility of fostering eugenic ideas call for transparency with children and for ensuring that guardians and researchers responsible for animals are sufficiently informed not only about recent findings but also about the existing knowledge gaps.

A final point addressed in the interviews was the role of Education and the importance of adequate teacher training as a means to promote students' critical development. Two values extracted from official documents were discussed: "Encouraging students to take a stance on controversial topics" (Value VI) and "Awareness of the influence of teachers' values and actions on students" (Value VII).

Although they were not able to define and differentiate conceptual and attitudinal content, the interviewees suggested methodological alternatives for addressing values in the classroom, involving a multidisciplinary and multidimensional approach. Proposed strategies included debates on the pros and cons of gene therapy, the use of simulations, and the discussion of scientific articles. In this regard, the assumption presented in education policy documents (São Paulo, 2019; Brasil, 2019; Brasil, 2020) about the relevance of discussing biotechnology, including its risks and potential benefits, was fulfilled. Education was mentioned as a space for social participation and as a form of oversight over the application of new technologies (P12 and P18).

Interviewees also mentioned positive outcomes of raising students' awareness about gene therapy during basic education, including their empowerment in the face of: sociocultural monopoly, high costs, and limited access to treatment (P18). Knowledge of ethical parameters would also serve as an advantage when dealing with situations involving the dissemination of inaccurate or incomplete information by healthcare professionals—whether due to intentions of increasing profitability, lack of empathy toward patients' naivety (P20), or their emotional vulnerability (P3).

Moreover, a broad and in-depth understanding of the topic would shield schools from the resurgence of eugenic principles (Sandel, 2015), as noted by P20, especially when supported by the promotion of values such as empathy, recognition of minority groups, and sensitivity to the topic (P20). These findings

Page | 10

Brazilian Journal of Science Teaching and Technology, Ponta Grossa, v. 19, p. 1-19, 2026.

are consistent with the perspectives of Gonçalves and Rosa (2020), who argue that addressing ethical consequences in the classroom would allow for more careful handling of attitudinal content, particularly when considering the multiplicity of perspectives and the complexity of defining boundaries for gene therapy (Segre; Ferraz, 1997).

At the end of the study, it was observed that, although the preservice teachers lacked extensive conceptual and procedural knowledge about gene therapy and still struggled to identify attitudinal content, they viewed the advances in genetic editing with caution and optimism. They frequently referred to ethical issues but lacked clear values to guide their reflections and decisions. Among the values extracted from the studied documents, the ones most frequently mentioned in both the questionnaire and interview phases were: "Concern with the ethical and social implications of gene therapy at the national and global level" (Value V); "Encouraging students to take a stance on controversial topics" (Value VI); and "Awareness of the influence of teachers' values and actions on students" (Value VII).

On the other hand, the least mentioned precepts were related to critical reflection on scientific explanation in comparison to other types of discourse on the topic, curiosity about understanding the processes involved, and interest in novelty. Ultimately, the importance of addressing the ethical implications of gene therapy in the classroom is revealed, particularly in the context of its application to human beings, with emphasis on human rights (United Nations General Assembly, 1998), cultural diversity, and legislative premises. A multidisciplinary treatment of the subject could be useful in encouraging critical reflection and curiosity about understanding the essential aspects of these therapies, consolidating a more comprehensive approach to teacher education.

FINAL CONSIDERATIONS

The study showed that undergraduate students in Biological Sciences, although open to the use of gene therapies, had little conceptual and procedural knowledge about the topic. Similarly, most of the sample did not show a predisposition for theoretical deepening before making decisions, and 40% of the participants, when questioned about attitudinal content, were only able to mention conceptual or procedural content.

All participants called for the interview phase also faced difficulties when required to explain attitudinal content, despite frequently recalling ethical issues related to the values of freedom and respect for autonomy. It was observed that only a portion of the values provided for in the documents that guide student and teacher education in Brazil were presented by the future biologists, among them: the values of "awareness of the relevance of preliminary testing and the participation of Ethics Committees in the decision to adopt new genetic treatments, valuing control mechanisms over science and companies" (Value III) and "concern for the ethical and social implications of gene therapy at both national and global levels" (Value V).

On the other hand, the least mentioned values were those related to "critical reflection on scientific explanation in comparison with other types of discourse on

the subject" (Value I); "curiosity about understanding the processes involved" (Value II); and "interest in novelties" (Value VIII).

Ultimately, the importance of addressing the ethical implications of gene therapy in the classroom is highlighted, particularly in the context of its application to human beings, with emphasis on human rights, cultural diversity, and legislative premises. A multidisciplinary approach to the topic could be useful in fostering critical reflection and curiosity about the essential aspects of these therapies, consolidating a more comprehensive approach to teacher education.

Page | 12

Brazilian Journal of Science Teaching and Technology, Ponta Grossa, v. 19, p. 1-19, 2026.

A TERAPIA GÊNICA E OS CONTEÚDOS ATITUDINAIS EM CIÊNCIAS BIOLÓGICAS

RESUMO

As terapias gênicas têm adquirido relevância redobrada na atualidade, penetrando nas mais diversas áreas sociais e alcançando níveis de desenvolvimento nunca antes vistos ou até mesmo pensados. Em função de sua importância, é imprescindível que a temática seja abordada no ensino básico e, por sua vez, seja objeto de estudo nos cursos de formação docente. OBJETIVOS: Nesse cenário, o presente trabalho teve como objetivo central a análise dos conteúdos atitudinais associados à terapia gênica entre estudantes de licenciatura em Ciências Biológicas, investigando os conhecimentos abordados na formação inicial docente, sua coerência com diretrizes educacionais vigentes e o posicionamento geral dos futuros professores sobre o tema. MÉTODOS: Os dados foram coletados por meio de um questionário (n = 20) e, num segundo momento, foram feitas entrevistas semiestruturadas (n = 5). RESULTADOS: Os resultados indicam que 20% da amostra não possuíam conteúdos conceituais básicos a respeito do tema, não sendo capazes de definir o termo "terapia gênica" de modo correto. Da mesma forma, 55% dos licenciandos não apresentaram predisposição para aprofundamentos teóricos antes da tomada de decisões e 40% dos participantes, quando questionados a respeito de conteúdos atitudinais, citaram apenas conteúdos conceituais ou procedimentais. Na fase das entrevistas, os estudantes apresentaram dificuldades em localizar valores, não foram capazes de descrever a diferença entre conteúdos conceituais e atitudinais e apenas dois dentre os cinco entrevistados trataram a temática de uma perspectiva multidimensional. Dos valores extraídos dos documentos estudados, aqueles comentados com maior frequência tanto na fase do questionário, quanto na fase da entrevista foram: "Preocupação com as implicações éticas e sociais da terapia gênica em âmbito nacional e em âmbito global"; "estímulo ao posicionamento dos alunos frente ao tema polêmico"; e "consciência da influência de seus valores e ações como professor sobre os alunos". CONSIDERAÇÕES FINAIS: Concluiu-se que há uma carência no tratamento multidisciplinar do assunto, particularmente no contexto da aplicação em seres humanos, com ênfase nos direitos humanos, na diversidade cultural e nas premissas legislativas. Enfatiza-se, desta forma, a necessidade de avanço no sentido de atender às expectativas nacionais em relação à formação docente estipuladas pelos documentos que a orientam e espera-se que os resultados aqui obtidos possam sinalizar caminhos para melhorias em futuras atualizações curriculares.

PALAVRAS-CHAVE: Genética. Ensino básico. Formação inicial de professores.

Page | 13

Brazilian Journal of Science Teaching and Technology, Ponta Grossa, v. 19, p. 1-19, 2026.

BIBLIOGRAPHIC REFERENCES

ASSEMBLEIA GERAL DA ONU. **Declaração Universal do Genoma Humano e os Direitos Humanos**. Resolução 53/111, 9 dez. 1998. Available at: https://unesdoc.unesco.org/ark:/48223/pf0000122990. Access on: Nov. 7th, 2022.

BRASIL. **Base Nacional Comum Curricular**: Educação Infantil e Ensino Fundamental. Brasília: MEC/Secretaria de Educação Básica, 2018. Available at: http://basenacionalcomum.mec.gov.br/. Access on: May 12th, 2023.

BRASIL. Conselho Nacional de Educação. **Resolução n. 2/2019, de 20 de dezembro de 2019**. Define as Diretrizes Curriculares Nacionais para a Formação Inicial de Professores para a Educação Básica e institui a Base Nacional Comum para a Formação Inicial de Professores da Educação Básica (BNC-Formação). Brasília, DF: 2019. Available at: https://abmes.org.br/legislacoes/detalhe/2982/resolucao-cne-cp-n-2. Access on: Jun. 30th, 2025.

BRASIL. Conselho Nacional de Educação. **Resolução n.1/2020, de 27 de outubro de 2020**. Dispõe sobre as Diretrizes Curriculares Nacionais para a Formação Continuada de Professores da Educação Básica e institui a Base Nacional Comum para a Formação Continuada de Professores da Educação Básica (BNC-Formação Continuada). Brasília, DF: 2020. Available at: https://portal.mec.gov.br/docman/outubro-2020-pdf/164841-rcp001-20/file. Access on: Jun. 30th, 2025.

DELMAS-MARTY, M. O universalismo dos direitos humanos em questão: o exemplo do direito à vida. *In*: TEIXEIRA, A. V.; OLIVEIRA, E. S. (org.). **Correntes contemporâneas do pensamento jurídico**. Barueri: Manole, 2010. Available at: https://www.manole.com.br/correntes-contemporaneas-do-pensamento-juridico/p. Access on: Jun. 30th, 2025.

DOMINGUES, D. S.; FÁVARO, R. D.; MAIA, I.; DINIZ, R. A discussão de tópicos de engenharia genética e biologia molecular na escola: o que pensam alunos de ensino médio. *In*: ENCONTRO NACIONAL DE PESQUISA EM EDUCAÇÃO EM CIÊNCIAS, 4., 2003, Bauru. **Anais** [...]. Bauru, SP: ABRAPEC, 2003. Available at: https://abrapec.com/atas_enpec/ivenpec/Arquivos/Painel/PNL011.pdf. Access on: Aug. 28th, 2023.

FÁVARO, R. D.; DINIZ, R. D. S.; MAIA, I. G.; DOMINGUES, D. S. Engenharia genética e biologia molecular: possibilidades e limites do trabalho do professor de biologia no ensino médio. *In*: ENCONTRO NACIONAL DE PESQUISA EM EDUCAÇÃO EM CIÊNCIAS, 4., 2003, Bauru. **Anais** [...]. Bauru, SP: ABRAPEC, 2003. p. 1-11. Available at:

Page | 14

Brazilian Journal of Science Teaching and Technology, Ponta Grossa, v. 19, p. 1-19, 2026.

https://abrapec.com/atas_enpec/ivenpec/Arquivos/Orais/ORAL073.pdf. Access on: Jan. 12th, 2023.

FERREIRA, K. E.; DE CASTRO RIBEIRO, P. A.; ROCHA, M. L.; DE JESUS COSTA, F.; MARTINS, É. M. Metodologias alternativas para o ensino de genética em um curso de licenciatura: um estudo em uma Universidade Pública de Minas Gerais. **Revista da Universidade Vale do Rio Verde**, v. 15, n. 1, p. 497-507, 2017. Available at: http://periodicos.unincor.br/index.php/revistaunincor/article/view/2790. Access on: Jan. 13th, 2023.

GAMBIN, K. C. **O ensino de genética no ensino médio do Brasil**: uma análise a partir de documentos e políticas educacionais e curriculares. 2022. Dissertação (Mestrado em Educação) — Universidade Federal da Fronteira Sul, Chapecó, 2022. Available at: https://rd.uffs.edu.br/bitstream/prefix/6435/1/GAMBIN.pdf. Access on: Jun. 30th, 2025.

GOLDIM, J. R. Genetics and ethics: a possible and necessary dialogue. **Journal of community genetics**, v. 6, p. 193-196, 2015. Available at: https://link.springer.com/article/10.1007/s12687-015-0232-6. Access on: Jan. 23rd, 2023.

GONÇALVES, M.; ROSA, R. Texto e construção de um posicionamento crítico. **Práticas Textuais**, n. 18, n. 19, p. 11-18, 2020. Available at: https://research.unl.pt/ws/portalfiles/portal/29476302/PraticasTextuais1819_12_19.pdf. Access on: Jan. 30th, 2023.

GUIMARÃES, S. S. M.; TOMAZELLO, M. G. C. Avaliação das idéias e atitudes relacionadas com sustentabilidade: metodologia e instrumentos. **Ciência & Educação**, Bauru, v. 10, p. 173-183, 2004. Available at: http://educa.fcc.org.br/scielo.php?pid=S1516-73132004000200003&script=sci_abstract. Access on: Jan. 30th, 2023.

JUSTINA, L. A. D.; RIPPEL, J. L. Ensino de genética: representações da ciência da hereditariedade no nível médio. *In*: ENCONTRO NACIONAL DE PESQUISA EM EDUCAÇÃO EM CIÊNCIAS, 4., 2003, Bauru. **Anais** [...]. Bauru, SP: ABRAPEC, 2003. Available at: https://fep.if.usp.br/~profis/arquivo/encontros/enpec/ivenpec/Arquivos/Orais/ORAL076.pdf. Access on: Feb. 4th, 2023.

LINDEN, R. Terapia gênica: o que é, o que não é e o que será. **Estudos avançados**, v. 24, n. 70, p. 31-69, 2010. Available at: https://www.scielo.br/j/ea/a/nmhVC8mrYSr9v68gRYRsPBS/?lang=pt. Access on: Mar. 17th, 2023.

Page | 15

Brazilian Journal of Science Teaching and Technology, Ponta Grossa, v. 19, p. 1-19, 2026.

LOPES, S. M. C. Ensino de Genética no Ensino Médio: desafios e novas perspectivas para qualidade da aprendizagem. **Research, Society and Development**, v. 12, n. 1, p. e7912139422-e7912139422, 2023. Available at: https://rsdjournal.org/index.php/rsd/article/view/39422. Access on: Jun. 30th, 2025.

MONTENEGRO, V. L. S. **O desenvolvimento do conhecimento pedagógico do conteúdo de professoras polivalentes no ensino de ciências**: um olhar acerca da influência de um curso de formação contínua sobre argumentação. 2017. Tese (Doutorado em Educação) – Universidade de São Paulo, São Paulo, 2017. Available at: https://www.teses.usp.br/teses/disponiveis/81/81132/tde-05072018-131725/en.php. Access on: Jan. 25th, 2023.

POZO, J. I.; CRESPO, M. A. G. **A aprendizagem e o ensino de ciências**: do conhecimento cotidiano ao conhecimento científico. Porto Alegre: Artmed, v. 5, p. 5, 2009. Available at: https://docente.ifrn.edu.br/mauriciofacanha/ensino-superior/disciplinas/instrumentacao-para-o-ensino-de-quimica-i/pozo-j.-i.-crespo-m.-a.-g.-a-aprendizagem-e-o-ensino-de-ciencias-do-conhecimento-cotidiano-ao-conhecimento-cientifico.-5.-ed.-porto-alegre-artmed-2009. Access on: Aug. 7th, 2023.

REBELO, D.; MENDES, A.; SOARES, R. Ensino da Biologia numa perspectiva CTS: um exemplo para a abordagem da unidade curricular – Património genético. *In*: PAIXÃO, F.; JORGE, F. R. (coord.). **Educação e Formação**: Ciência, Cultura e Cidadania, p. 264-271, 2009. Available at: https://www.researchgate.net/profile/Rui-Soares-12/publication/256090734_O_ensino_da_Biologia_numa_perspectiva_CTS_um_exemplo_para_a_abordagem_da_unidade_curricular_-_Patrimonio_genetico/links/00463521a381c7c9e4000000/O-ensino-da-Biologia-numa-perspectiva-CTS-um-exemplo-para-a-abordagem-da-unidade-curricular-Patrimonio-genetico.pdf. Access on: Apr. 16th, 2023.

RIBEIRO, C. M. C. **Aprendizagem cooperativa na sala de aula**: uma estratégia para aquisição de algumas competências cognitivas e atitudinais definidas pelo Ministério da Educação. 2006. Tese (Doutorado em Educação) – Universidade de Trás-os-Montes e Alto Douro, Vila Real, Portugal, 2006. Available at: https://www.proquest.com/docview/2701131966?fromopenview=true&pq-origsite=gscholar&sourcetype=Dissertations%20&%20Theses. Access on: Feb. 8th, 2023.

SANDEL, M. J. **Contra a perfeição**: ética na era da engenharia genética. Editora José Olympio, 2015. Available at: https://www.anpof.org/periodicos/conjectura-filosofia-e-educacao/leitura/712/25583. Access on: Mar. 15th, 2023.

SÃO PAULO (Estado). Secretaria da Educação. **Currículo Paulista**: primeiro e segundo ciclo do ensino fundamental e ensino médio. São Paulo: SEE, 2019.

Page | 16

Brazilian Journal of Science Teaching and Technology, Ponta Grossa, v. 19, p. 1-19, 2026.

Available at: https://efape.educacao.sp.gov.br/curriculopaulista/. Access on: May. 11th, 2023.

SÃO PAULO (Estado). **Catálogo das Ementas detalhadas dos Aprofundamentos Curriculares**. Secretaria da Educação do Estado, 2022. Available at: https://curriculomais.educacao.sp.gov.br/2019/01/22/catologo-dos-aperfundamentos-curriculares/. Access on: May. 11th, 2023.

SCHNEIDER, E. M. **Alfabetização científica de alunos do ensino superior frente às implicações da engenharia genética e a idealização do "melhoramento humano"**. 2015. Dissertação (Mestrado em Ensino de Ciências) – Universidade Federal do Rio Grande do Sul, Porto Alegre, 2015. Available at: http://repositorio.uem.br:8080/jspui/handle/1/4557. Access on: Jan.25th, 2023.

SCHNEIDER, E. M.; MEGLHIORATTI, F. A.; CORAZZA, M. J. Discursos de professores em formação continuada acerca da relação entre a manipulação genética e a possibilidade de melhoramento em humanos. **Ciência & Educação**, Bauru, v. 22, p. 597-613, 2016. Available at: https://www.scielo.br/j/ciedu/a/kHrkFVMdsR9kCPGLyqYJLJM/?lang=pt&format=html. Access on: Aug. 23rd, 2023.

SEGRE, M.; FERRAZ, F. C. O conceito de saúde. **Revista de Saúde Pública**, v. 31, p. 538-542, 1997. Available at: https://www.scielo.br/j/rsp/a/ztHNk9hRH3TJhh5fMgDFCFj/?stop=next&format=html. Access on: May 12th, 2023.

SMITH, D. **Ethical Issues in Research**: A Guide for Students. 1st ed. New York: Routledge, 2015. Available at: https://www.routledge.com/Research-Ethics/SmithIltis/p/book/9780415472975. Access on: Feb. 4th, 2023.

SOUSA, E. S; ALMEIDA, A. C. P. C. Ensino-aprendizagem de conteúdos de biodiversidade e genética com ênfase em ciências, tecnologia e sociedade. **Ciência & Educação**, Bauru, v. 23, n. 2, p. 331-346, 2017. Available at: https://repositorio.ufpa.br/handle/2011/12428. Access on: Apr. 16th, 2023.

XAVIER, M. C.; FREIRE, A. S.; MORAES, M. O. A introdução dos conceitos de biologia molecular e biotecnologia no ensino de genética no nível médio: há espaço para a nova biologia? *In*: ENCONTRO NACIONAL DE PESQUISA EM EDUCAÇÃO EM CIÊNCIAS, 5., 2005, Bauru. **Anais** [...]. Bauru, SP: ABRAPEC, 2005. p. 1-12. Available at: https://abrapec.com/atas_enpec/venpec/conteudo/oralarea8.htm. Access on: Aug. 23rd, 2023.

ZABALA, A. **A prática educativa**: como ensinar. Penso Editora, p. 27-52, 2015. Available at: https://books.google.com.br/books?hl=pt-BR&lr=&id=ypR9CAAAQBAJ&oi=fnd&pg=PT162&dq=ZABALA,+A.+A+pr%C3%A1tic a+educativa:+como+ensinar.+Penso+Editora,+p.+27-52,+2015.&ots=xyyj-IMr0E&sig=q2uhffkz00O8ag7q25eKs7OgBng&redir_esc=y#v=onepage&q&f=fals. Access on: Feb. 4th, 2023.