



Systematic review of Science teacher education and giftedness

Revisión sistemática de la formación docente en Ciencias y superdotación

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Abstract

This study conducted a systematic review of the national literature published between 2019 and 2024, with the aim of mapping and analyzing the education of Science teachers (Biology, Chemistry, and Physics) at the interface with Special Education, focusing on students with High Abilities/Giftedness. The analysis of 18 selected studies revealed four main thematic categories: initial teacher education curricula; teachers' conceptions regarding this specificity; pedagogical strategies and resources aimed at this population; and professional development actions in Science from an inclusive perspective. The results point to persistent gaps in teacher education, particularly in Physics, as well as misconceptions about giftedness, an uneven distribution of scientific production across the country, and a concentration of research within Graduate Programs. Despite these limitations, innovative initiatives stand out, such as inquiry-based experimentation, the STEAM approach, remote mentoring, gamification, and the use of active methodologies, which contribute to the recognition and development of these students' potential. It is concluded that initial and continuing education of Science teachers, articulated with Special Education, is essential for consolidating inclusive and equitable pedagogical practices; however, it is necessary to establish parameters for monitoring and evaluating the impact of these educational initiatives in Brazilian public Basic Education classrooms.

Keywords: teacher professional development, science education, giftedness, educational diversity, systematic review, special education.

Resumen

Este estudio realizó una revisión sistemática de la literatura nacional, publicada entre 2019 y 2024, con el objetivo de mapear y analizar la formación de docentes de Ciencias (Biología, Química y Física) en interfaz con la Educación Especial, dirigida a estudiantes con Altas Habilidades/Superdotación. El análisis de 18 estudios seleccionados reveló cuatro categorías temáticas principales: currículo de la formación inicial docente; concepciones de los docentes sobre esta especificidad; estrategias y recursos pedagógicos dirigidos a esta población; y acciones formativas en Ciencias desde una perspectiva inclusiva. Los resultados destacan brechas persistentes en la formación docente, especialmente en el área de Física, así como concepciones erróneas sobre la superdotación, distribución desigual de la producción científica en el territorio nacional y concentración de la investigación en Programas de Posgrado. A pesar de estas limitaciones, se destacan iniciativas innovadoras, como la experimentación investigativa, el enfoque STEAM, la mentoría remota, la gamificación y el uso de metodologías activas, que contribuyen al reconocimiento y desarrollo del potencial de estos estudiantes. Se concluye que la formación inicial y permanente de profesores de ciencias, vinculados a la educación especial, es esencial para la consolidación de prácticas pedagógicas inclusivas y equitativas; sin embargo, es necesario establecer parámetros para monitorear y evaluar el impacto de esta formación en las aulas de la educación básica pública brasileña.

Palabras clave: desarrollo profesional docente, educación científica, superdotación, diversidad educativa, revisión sistemática, educación especial.

1. Introduction

In contemporary educational debates, teacher training has taken center stage, as social, political, and technological changes demand professionals who are trained to work with diversity in schools. According to Saviani (2009), the role of initial training is to articulate theory and practice, overcome technocratic models, and strengthen teacher identity, assuming a political commitment to teaching and school democratization. According to Nóvoa (2009), continuing education should contribute to valuing the human and ethical dimensions of the profession, supporting autonomy and collaboration among teachers, and promoting professional development. Both authors criticize technocratic models and argue that initial and continuing education should be integrated and linked to everyday school life.

In the field of Special Education (Brazil, 2025), a cross-cutting teaching modality that offers services and school support to students with disabilities, autism spectrum disorder (ASD), and high abilities or giftedness (HA/GD), teacher training plays a fundamental role in the development of inclusive school practices. In the case of students with AH/SD, it is essential that teachers be able to identify and support their talents, for example, in the area of Natural Sciences, by creating stimulating environments (Renzulli, 1978; Alencar and Fleith, 2010), thereby contributing to equitable, high-quality science education (Carvalho, 2013; García, 2015).

Several countries have emphasized teacher training to recognize and promote gifted and talented students, articulating theory, practice, and equity (Townend et al., 2024; Weber and Mofield, 2023). In the United States, the standards of the National Association for Gifted Children (NAGC) highlight teacher training as essential for serving gifted students, while in Australia, the High Potential and Gifted Education Policy (2019) establishes continuing education as a requirement for working with this population. These trends highlight the importance of recognizing diversity of talents and developing creativity, inquiry, and critical thinking, bringing Brazil closer to a global movement of inclusion and appreciation of cognitive diversity.

Corroborating these perspectives, there is a clear need for consistent initial and continuing training, articulated with the principles of special

and inclusive education, and for advances in empirical research on its impact on the recognition and support of student with giftedness in regular education. In Brazil, teacher training aimed at this population is still incipient, especially in the teaching of Natural Sciences, and despite advances in inclusive policies, there is a lack of studies on teacher preparation focused on identifying and supporting students with high potential.

Given this scenario, this study investigates national academic production on the training of Natural Sciences teachers in the context of student with giftedness, contributing to the theoretical strengthening and improvement of inclusive training policies and practices. Thus, this research seeks to map and analyze the scientific literature published in Brazil between 2019 and 2024 that addresses the training of science teachers (biology, chemistry, and physics) for special education in this context. The intention is to identify emerging thematic categories and perform a bibliometric characterization based on articles, dissertations, and theses, synthesizing existing scientific evidence to provide reliable, data-driven support for decision-making in training policies and practices.

We understand that the importance of analyzing national academic production allows us not only to identify gaps in teacher training but also to guide policies, professional development programs, and future research that strengthen teachers' ability to recognize, stimulate, and support the diversity of talents present in Brazilian classrooms, consolidating a scientific education that values cognitive plurality and enhances the learning of all students. Below, we will present the methodology used in the research.

2. Methodology

This study adopts a systematic literature review model based on the PRISMA (*Preferred Reporting Items for Systematic Reviews and Meta-Analyses*) 2020 model, whose inclusion of studies is based on four stages: identification (survey of available studies), screening (evaluated based on reading titles and abstracts), eligibility (based on reading the full text) to finally identify the included studies that will form the basis of the analyses and conclusions. The focus of the research is on the thematic units present in Brazilian productions that address teacher training in the area

of Natural Sciences (Chemistry, Physics, and Biology), aimed at the school inclusion of student with giftedness, terminology used by Brazilian legislation (Brazil, 2025). The main objective was to identify recurring categories, highlight trends, and recognize theoretical gaps related to the topic.

To achieve this purpose, scientific studies available in comprehensive and relevant databases were selected, specifically in the Brazilian Digital Library of Theses and Dissertations (BDTD) and in journals indexed in the CAPES Journal Portal. Inclusion and exclusion criteria were defined to cover as many studies as possible relevant to the research topic, ensuring the breadth of the search, methodological rigor, and consistency in the selection of the material analyzed.

The time frame adopted was from 2019 to 2024, justified by the changes promoted by Resolution CNE/CP No. 2/2019, which redefined the guidelines for teacher training in Brazil. According to authors such as Libâneo (2023), Zucchini (2023), and Rocha et al. (2022), this regulation reinforced a more technical and instrumental nature of training processes, reducing the space allocated to critical, reflective, and inclusive approaches, a particularly sensitive aspect in the education of student with giftedness. The searches were conducted between April 2024 and May 2025.

Step 1 — Identification

In this phase, studies were retrieved from the databases of the Coordination for the Improvement of Higher Education Personnel (CAPES), the Brazilian Digital Library of Theses and Dissertations (BDTD), and the Scientific Electronic Library Online (SciELO). Based on this survey, an initial sample of studies was constructed according to previously defined inclusion and eligibility criteria, such as:

- The use of the terms: (1) Science teacher training and giftedness; (2) Science teacher training and giftedness, limiting the search to their appearance in the title, abstract, and keywords of the articles.
- The use of four combinations of descriptors with the Boolean operator “AND” (Universidade Federal do Rio Grande do Sul, 2022; Picalho et al., 2022) considering titles, abstracts, and keywords for academic

papers: (1) Education AND Chemistry AND giftedness; (2) Education AND Physics AND giftedness; (3) Education AND Science AND giftedness; (4) Education AND Biology AND giftedness.

These combinations were defined to cover the different areas of Natural Sciences, maintaining a focus on teacher training oriented towards the inclusion of students with AH/SD.

- Define the type of document as a parallel inclusion criterion, selecting in this first phase journal articles and academic papers (dissertations and theses) linked to national postgraduate programs (PPG), excluding papers presented at conferences, books, and book chapters.

After applying these criteria, the first search yielded a total of 82 records. After eliminating 22 duplicate records, a final set of 60 valid publications was obtained for the next screening stage.

Stage 2 — Screening

In this step, to delimit the sample and ensure that the studies met the defined criteria and the focus of the review, without the use of automation tools, the titles and abstracts of the studies were examined, and the following additional exclusion criteria were defined:

- Studies in the area of Physical Education, resulting from the misuse of the descriptor “Training AND Physical AND giftedness” (n = 10).
- Publications prior to 2019 (n = 15).

In total, 25 studies were excluded and 35 were eligible for the next stage.

Step 3 — Eligibility

At this stage, the full text of the 35 eligible studies was read, and 17 studies were excluded because they were considered inappropriate and their objectives diverged from the focus of this review. The exclusion criteria adopted were:

- Studies not related to the natural sciences (n = 13).
- Studies not related to the final years of primary or secondary education, but rather to the training of educators working in the early years of primary education or addressing initial teacher training (n = 3).
- The study deviated from the objectives and focus of the review because it was a study of twice-exceptionality and not teacher training, but rather psychology (n = 1).

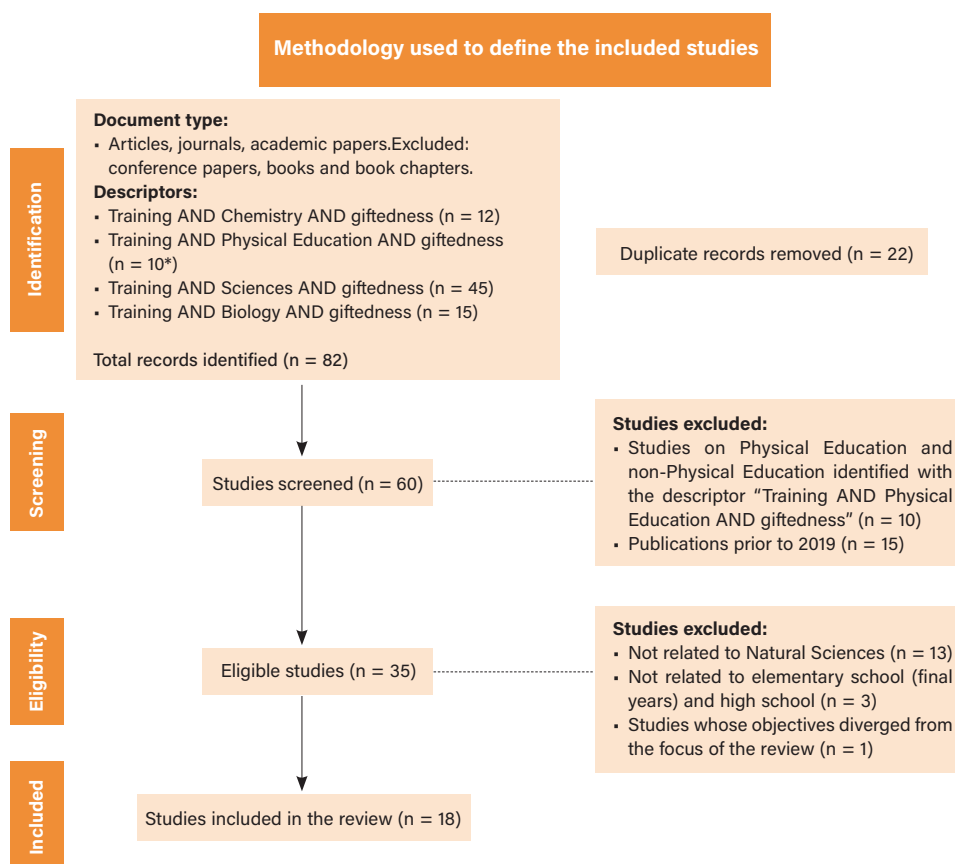
Given the qualitative nature of the review, risk of bias was assessed by restricting the analysis to indexed articles, dissertations, and theses, recognizing that unpublished studies may contain additional information. In addition, two independent reviewers analyzed each study, and discrepancies were resolved

by consensus to ensure consistency with the review's focus and objectives, as well as to ensure methodological rigor and thematic relevance.

Step 4 — Inclusion

Upon completion of the selection and eligibility stages, the authors of this study independently and by consensus selected 18 studies considered relevant to the scope of the research, as they addressed teacher training in CN, focusing on the school inclusion of students with AH/SD in basic education (final years of primary and secondary school). Finally, the PRISMA flow diagram is presented, which summarizes in an organized way all the stages of the search, selection, eligibility, and inclusion process, resulting in a final sample of 18 studies, as shown in Figure 1.

Figure 1. PRISMA diagram of the systematic review process



Data analysis followed the PRISMA 2020 guidelines, which guide the conduct and reporting of systematic reviews in a transparent and reproducible

manner (Page et al., 2021). The protocol includes a checklist that organizes steps such as eligibility criteria, search strategies, study selection, synthesis

of results, and risk of bias assessment, as well as a flowchart detailing the process of study selection, identification, eligibility, and inclusion. The use of these guidelines ensured greater rigor and clarity at all stages of the review.

The review, record selection, and data extraction were performed independently by the authors, and any disagreements were resolved by consensus without using automated systems. For each study, information was collected on the area of Natural Sciences, the type and method of research, the content and strategies of teacher training, and its relationship with students with AH/SD.

The authors of this review recorded and resolved missing or ambiguous information. The variables analyzed included aspects of teacher training (including content, strategies, and inclusive approach), the area of Natural Sciences addressed (Chemistry, Physics, or Biology), the educational context related to Basic Education, and the type of publication (article, dissertation, or thesis).

Additional characteristics were also recorded, such as the year of publication, authorship, geographical region of origin, and the graduate program responsible for the production. The assessment of

bias risk, appropriate for the qualitative nature of the review, focused on the clarity of the studies' objectives, methodological consistency, and thematic relevance. The synthesis of results was descriptive and comparative, as no meta-analysis was performed. Following the PRISMA guidelines (2020), eligible studies were classified by area of Natural Sciences and type of publication, and then tabulated and compared. The analysis allowed identifying thematic categories and bibliometric patterns, highlighting gaps in science teacher training, especially in physics for gifted and talented students, and pointing to emerging trends in the field.

A meta-analysis was not performed due to the methodological and thematic heterogeneity of the included studies. The assessment of publication bias considered the limitation derived from the exclusive inclusion of indexed articles, dissertations, and theses, recognizing that unpublished works could provide additional evidence. The certainty of the evidence was examined based on the consistency of the findings, the relevance to the topic under investigation, and the methodological rigor of the selected publications.

These studies comprise the *analytical corpus* and are organized below in Table 1.

Table 1. Studies selected after a search conducted in BDTD, CAPES, and SciELO

Código	Referência
E1	Rocha-Oliveira, R., Dias, V. B., & Siqueira, M. (2019). Formação de professores de Biologia e educação inclusiva: Índicios do Projeto Acadêmico Curricular. <i>Revista Brasileira de Pesquisa em Educação em Ciências</i> , 19, 225–250.
E2	Nicácio, J. L. (2019). <i>Formação de professores para o uso do software educacional HagáQuê no ensino de alunos com AH/SD</i> (Dissertação de Mestrado). Universidade Federal do Acre.
E3	Souto, K. C., Castro, H. C., & Delou, C. M. C. (2021). Da formação básica à prática docente: Qual a percepção do professor sobre a superdotação? <i>Travessias</i> , 15(2).
E4	Adams, F. W. (2021). Educação Especial na formação inicial de professores de Ciências da Natureza: Em foco os eventos científicos. <i>Revista Triângulo</i> , 14(2), 241–261.
E5	Brunetti, D. T. A. (2022). <i>Formação inicial de professores no curso de Licenciatura em Ciências Biológicas com foco nas altas habilidades e superdotação: Reflexões sobre a prática pedagógica e experiências inclusivas</i> (Dissertação de Mestrado). Universidade Estadual do Centro-Oeste.
E6	Brunetti, D. T., & Crisostimo, A. L. (2022). Formação inicial com foco nas altas habilidades/superdotação: Práticas inclusivas em Ciências Biológicas. <i>Amazônia: Revista de Educação em Ciências e Matemática</i> , 18, 188–203.
E7	Nóbrega, L. N. N. (2022). <i>A experimentação investigativa na sondagem de indicadores de Altas Habilidades ou Superdotação e na potencialização no ensino de Química</i> (Tese de Doutorado). Universidade Federal de Goiás.
E8	Nóbrega, L. N., Nobre-da-Silva, N. A., & Benite, C. R. M. (2022). Interface entre ensino de Química e Educação Especial: Pressupostos teóricos para atendimento a estudantes com AH/SD. <i>ACTIO</i> , 7(3), 1–23.
E9	Ferreira, O. (2023). <i>Altas habilidades/superdotação e o ensino de Ciências: Reflexões sobre a inclusão na Educação Básica</i> (Dissertação de Mestrado Profissional). Universidade Federal do Pará.
E10	Xavier, M. B. (2023). <i>Mentoria de enriquecimento remoto na pandemia: Estudo de caso retrospectivo em AH/SD</i> (Dissertação de Mestrado). Universidade Federal Fluminense.
E11	Lima, F. S. C. de. (2023). <i>Resolução de Problemas como metodologia de ensino para educação inclusiva</i> (Tese de Doutorado). Universidade Federal do Rio Grande do Sul.

- E12 Salgado, A. R. D. (2023). Iniciação científica no contexto das altas habilidades ou superdotação. *Revista Brasileira de Altas Habilidades/Superdotação*, 5, 3–25.
- E13 Salgado, A. R. D. (2023). *Protagonismo juvenil e enriquecimento psicopedagógico remoto no ensino de Ciências para altas habilidades com vocação científica* (Tese de Doutorado). Universidade Federal Fluminense.
- E14 Salgado, M. L. C. (2024). *A identificação de alunos com AH/SD na perspectiva de professores da Educação Básica* (Dissertação de Mestrado). Pontifícia Universidade Católica de São Paulo.
- E15 Nóbrega, L. N. N., & Benite, C. R. M. (2024). A experimentação investigativa no ensino de Química para sondagem de indicadores de AH/SD. *Amazônia*, 20, 191.
- E16 Reis, M. dos S., Almeida, A. S., Souza, F. dos S., & Dias, V. B. (2024). A formação inicial de professores de Ciências Naturais e educação inclusiva: Caminhos já percorridos nas pesquisas. *Educação: Teoria & Prática*, 34(67), e11.
- E17 Ferreira, A. C. (2024). *Caracterização das ações docentes e discentes em aulas de Química para estudantes com AH/SD* (Tese de Doutorado). Universidade Estadual de Londrina.
- E18 Mateus, A. C. R. (2024). *Estudo sobre características da abordagem STEAM como possíveis indicadores de AH/SD na área de Ciências da Natureza* (Dissertação de Mestrado). Universidade Federal de Goiás

3. Results and discussion

The analysis of the 18 eligible files revealed two central dimensions. The first covers four thematic categories: (1) Initial teacher training curriculum in science at the interface with special education; (2) Teachers' conceptions of student with giftedness in science; (3) Pedagogical strategies and resources for student with giftedness; and (4) Training actions in the field of student with giftedness in science, highlighting persistent gaps in teacher training, especially in the area of physics focused on student with giftedness.

The second dimension corresponds to the bibliometric characterization of the studies, including the annual distribution of publications, geographical location, institutional affiliations, graduate programs involved, and areas of knowledge researched. We discuss both dimensions below.

3.1 Thematic categories

3.1.1 Curriculum for the initial training of science teachers at the interface with special education

Inclusive education gained momentum in Brazil in the 1990s, influenced by international documents such as the Salamanca Statement (UNESCO, 1994). However, a comparison of data from recent studies within science degree programs shows that this topic is still treated superficially. In most institutions, discussions on inclusion focus on specific subjects, such as Brazilian Sign Language (LIBRAS), recognized as a second language by Decree No. 5,626/2005, or on elective components, revealing the

fragility of the integration of inclusive education in initial teacher training (Rocha-Oliveira et al., 2019; Ferreira, 2023; Reis et al., 2024). This limitation highlights the inertia of undergraduate programs in the face of the demands imposed by the growing presence of students who are the target audience of special education (Pedroso et al., 2013; Vilela-Ribeiro and Benite, 2011b).

Although some current curricula offer some flexibility for undergraduate students to bring the demands of the school to the university, opening space for debates on diversity, they are still far from complying with the provisions of the National Guidelines for Teacher Training (2002 and 2015), which reinforce the need to prepare teachers to act with equity and inclusion. Given these shortcomings, several authors (Adams, 2021; Rocha-Oliveira et al., 2019; Reis et al., 2024) argue that supervised practices, outreach activities, and participation in scientific events constitute privileged spaces for articulating science education with inclusive education, fostering experiences more in line with the diversity present in the school context.

3.1.2 Teachers' conceptions of student with giftedness in science

Research by Shulman, Schön, Fullan, Calderhead, and Borg show that teachers' conceptions and beliefs directly influence their pedagogical decisions, guiding planning, teaching strategies, and the interpretation of classroom situations. In the case of student with giftedness, these conceptions are often steeped in myths and misconceptions, which is one of the main obstacles to identifying gifted students in regular public schools. Among these myths, the idea

that gifted students must excel in all areas stands out (Winner, 1996), leading many teachers to fail to recognize specific talents or cases in which HA/GD coexists with learning difficulties (Pérez, 2011, p. 515).

When analyzing the research by Souto, Castro, and Delou (2021), we perceive that entrenched conceptions continue to negatively influence teaching practice in Brazilian schools. The authors point out that both university students and science teachers have a superficial understanding of HA/GD, even after teaching experiences or additional training. The authors' data indicated that 30% of teachers and more than 55% of university students considered AH/GD to be a rare phenomenon, and about 10% believed it was more common in boys, revealing gender biases (Pérez and Freitas, 2012). In addition, 11% of teachers and 20% of university students associated this condition with psychological problems without scientific support, corroborating the myths pointed out by Winner (1996). The insufficient coverage of the topic in university programs makes it difficult to recognize gifted students, and isolated training courses do not promote significant changes in teachers' conceptions. Therefore, it is argued that training programs should include evidence-based professional development indicators, ensuring a real impact on teaching practice.

Another study that offered relevant insights into how elementary school teachers perceive and address challenges related to HA/GD in the school context was conducted by Ferreira (2023). The author collected the opinions of teachers in the municipal school system responsible for teaching science in the early years of primary school—i.e., pedagogues—and found that, although these professionals had more than ten years of classroom experience and postgraduate training, they still understood giftedness primarily as intellectual abilities associated with academic performance. This perspective corresponds to the type of academic giftedness characterized by “ease of learning”; precisely, the type of skill most valued in traditional schools, which prioritize analytical skills over creative or practical ones (Renzulli, 2004). As a result, teachers dismissed other types of giftedness identified by this author, such as creative-productive giftedness or mixed-profile giftedness.

Knowing that the identification of students with indicators of AH/GD depends directly on the

teacher's perception in the daily school routine, Salgado's study (2024) highlights how misconceptions can lead to inaccurate interpretations. In his research with three elementary school teachers, confusion was observed between indicators of potential and characteristics of learning disorders or difficulties: Teacher 1 attributed a student's ease of learning solely to the cultural environment, ignoring innate aspects and reproducing a gender interpretation; Teacher 2 did not recognize the high cognitive and creative potential of a girl with autism spectrum disorder (ASD), even though she was also identified with HA/GD; and Teacher 3 interpreted difficulties related to frustration and symbolic thinking as a sign of autism. These misconceptions reflect myths described by Winner (1998), Renzulli (2004), and Virgolim (2007), such as the false opposition between innate and acquired talent and the belief that inattentive or unmotivated behaviors indicate a lack of ability. These stereotypes end up obscuring potential and reducing opportunities for educational enrichment.

3.1.3 *Strategies and pedagogical resources for student with giftedness*

International strategies for identifying giftedness follow a multidimensional approach that combines cognitive testing, creativity assessment, portfolios, and systematic observation to reduce bias and recognize different talent profiles (Renzulli, 2004; Sternberg, 2017; Gagné, 2009). Countries such as the United States, Canada, Australia, and the United Kingdom use instruments such as WISC-V, CogAT, Raven, behavior scales (Renzulli et al., 2002), and divergent thinking tests, such as the TTCT (Torrance, 1974). Practices such as universal screening increase inclusion (Peters et al., 2019), while dynamic assessment models, especially in Israel, allow for the identification of learning potential beyond current performance (Feuerstein, 1980). Therefore, the international trend is to adopt continuous and diversified processes carried out by multidisciplinary teams.

In Brazil, although legislation proposes a multifactorial assessment that considers cognitive, creative, and socio-affective aspects (Pérez, 2009), its implementation is still limited and depends on coordination between schools and the Centers for High

Ability/Giftedness (NAAH/S), created in 2005, and which are marked by strong regional inequalities. Despite this scenario, recent research has sought to develop methodological procedures that simultaneously help identify and empower student with giftedness. Among them, Nóbrega (2022) stands out. Based on Renzulli's School Enrichment Model (2004, 2014), she used investigative experimentation in chemistry teaching to track indicators of HA/GD in a public school in Goiás. The analysis of the activities made it possible to distinguish common cognitive skills from higher metacognitive skills. In another study from the same year, the author developed teaching materials aimed at combating fake news on socio-scientific topics, expanding conceptual repertoires, stimulating creative and social skills, and promoting high student engagement, highlighting their potential for talent development in the field.

Similarly, Mateus (2024) investigated the potential of the STEAM (Science, Technology, Engineering, Arts, and Mathematics) approach for detecting indicators of HA/GD in science. The author analyzed a challenge applied to high school students that consisted of building a prototype to solve a hypothetical problem: allowing a blind mother to correctly measure the volume of medication to medicate her child. The activity made it possible to assess cognitive and metacognitive skills, as well as the creativity employed in the solutions presented by the students. The results showed that the STEAM approach favors the identification of high potential, although the author highlighted the limitations of inferring indicators of HA/GD from a single assessment activity.

Another initiative identified in the studies analyzed occurred in the context of remote teaching during the pandemic, when Xavier (2023) examined how a Remote Enrichment Mentoring (REM) program met the cognitive and motivational demands of a primary school student with HP/SD who was particularly interested in arthropods. The research, which was qualitative and descriptive in nature, collected data through digital platforms such as WhatsApp and Google Meet, involving the mentored student and three university students who acted as mentors. According to the author, the REM met the student's intellectual needs, compensated for the absence of practical and laboratory activities, ensured individualized support, and even resulted in the creation of

a mentoring training course for future teachers and administrators. However, further methodological details could not be explored because the thesis was not available in open access.

Salgado's (2023) research, conducted during the pandemic, investigated the use of playful and technological formats for scientific communication as a strategy to identify signs of HA/GD in students with early scientific aptitude. The author promoted enrichment activities based on gamification and active methodologies, which culminated in the production of an interactive almanac and a digital game. The results showed that teacher mediation encouraged students' active participation in the search for educational and technological resources, in the design of research, and in the development of autonomy and collaboration skills, strengthening their scientific vocation. In combination with other studies analyzed, this research indicates that although Brazil does not yet have comprehensive and formalized identification systems such as those adopted internationally, investigative, active, and technology-mediated methodologies have proven to be promising ways to recognize and stimulate student with giftedness, highlighting the need for structured policies and greater investment in teacher training.

3.1.4 Science training activities at the interface with HA/GD

Although education legislation recognizes student with giftedness as part of the special education population (Brazil, 1996), there remains a significant gap in teacher training, which compromises identification and support practices. The studies analyzed show that training activities—such as courses, workshops, internships, seminars, mentoring, educational products, and the use of technologies—play a central role in providing theoretical and methodological support for identification in childhood and for planning appropriate pedagogical strategies. In the context of initial teacher training, supervised internships have proven to be a strategic space for incorporating discussions about student with giftedness, although they are still under-explored (Salto, 2020; Reis et al., 2024). In this context, Brunetti (2022) implemented a training course for undergraduate students in Biological Sciences, observing conceptual advances after the intervention, while Lima (2023)

used the *Problem-Based Learning* methodology with undergraduate students in Chemistry and Biology, promoting reflections on Special Education. In continuing education, Xavier (2023) developed seminars that resulted in the production of a digital book to enrich scientific practices; Ferreira (2024) conducted a seminar focused on the characterization of teaching and learning actions in Chemistry classes for student with giftedness, indicating that the topic remains underrepresented in training policies; and Nicácio (2019) offered a course on the use of the educational software *HagáQuê*, demonstrating its potential to foster challenging and creative practices with student with giftedness. In a systematized action, Souto et al. (2021) compared the perceptions of university students and practicing teachers in the field of science, concluding that continuous education has not significantly broadened the understanding of giftedness, highlighting the need for greater articulation between school management, teacher training, and the real demands of the classroom, a scenario that has led many teachers to seek training independently.

Even in initial training, Adams (2021) identified low participation by science students in events on special education due to lack of knowledge, although such experiences can broaden debates and strengthen training.

On the other hand, Ferreira (2024) analyzed the actions of teachers and students in chemistry classes, highlighting variations according to the pedagogical strategy adopted and identifying evidence of learning in the interactions that took place. Nóbrega (2022), when interviewing a specialist from NAAH/S-GO, articulated theoretical assumptions to guide interventions in chemistry, highlighting inquiry and experimentation as central strategies for identifying indicators of HA/GD. Finally, Salgado (2023) developed a guidebook with innovative practices in science and biotechnology, illustrating the

potential of training actions to improve teaching and empower student with giftedness.

These categories highlight the challenges, but also the possibilities, for recognizing students with this profile in science within public basic education. They reveal difficulties such as the lack of identification and teacher training policies, but also indicate that active methodologies, research, technologies, and qualified mediation can favor this recognition, suggesting ways to strengthen teacher support and training.

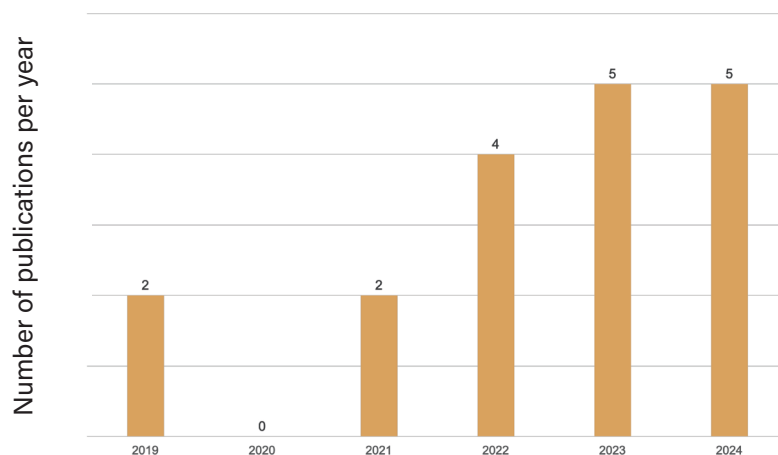
3.2 Bibliometric characterization

Bibliometrics has been used in science as “a statistical technique used to measure aspects of academic production that contribute to the development of science” (Medeiros and Vitoriano, 2015, p. 491), highlighting patterns in the research topic, especially in terms of the temporal distribution of publications, geographical location, and the PPG institutions involved.

3.2.1 Temporal distribution

The distribution presented in Figure 2 illustrates the panorama of scientific production on teacher training in science focused on HA/GD in the period 2019 to 2024. It can be seen that the number of publications decreases in the early years, with only two studies identified in 2019 and no records in 2020, a gap possibly related to the impacts of the COVID-19 pandemic on research and postgraduate activities in the country. From 2021 onwards, a gradual recovery is observed, followed by significant growth from 2022 to 2023 and linear growth from 2023 to 2024. This movement indicates a growing interest in the topic among the academic community, while also revealing the strengthening and consolidation of research at the interface between teacher training and service to the Special Education population, especially in the context of student with giftedness.

Figure 2. Temporal distribution of academic publications



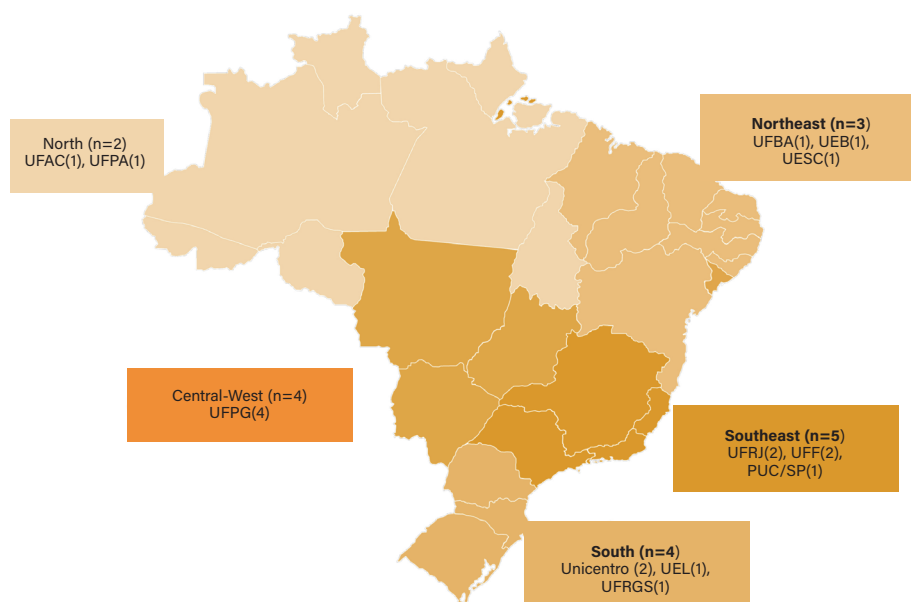
3.2.2 Geographical location of research

Scientific production on HA/GD in Brazil is unevenly distributed, with the highest concentration in the Southeast region, followed by the South and Midwest regions, while the Northeast and North regions have the lowest participation. In the Southeast, institutions such as UFF and UFRJ stand out, developing research focused on diversity and inclusion. Likewise, Unicentro maintains two lines of research focused on educational policies, culture, and diversity, with a strong emphasis on inclusive processes. UFG also stands out for its structured

programs and collaborative networks, such as RPEI, linked to the Laboratory for Research in Education and Chemical Inclusion (LPEQI).

In the Northeast, the three studies identified are concentrated in universities in the state of Bahia, while in the North there are only two studies, developed by UFAC and UFPA. This regional concentration reduces theoretical and methodological diversity and limits the visibility of local demands, as well as influencing the formulation of public policies based on the most active academic centers. Despite these asymmetries, there has been an expansion of the topic and the strengthening of new research centers and networks dedicated to HA/GD.

Figure 3. Geographic location of research



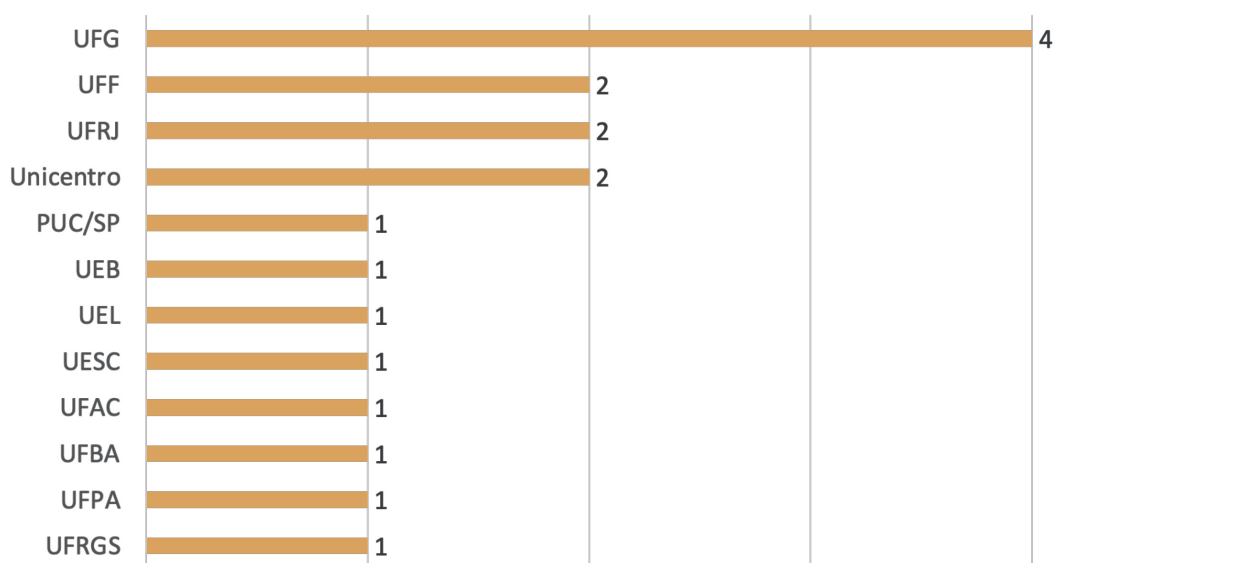
3.2.3 Institutions involved

An analysis of the various institutions and their respective postgraduate programs reveals that scientific output on teacher training in science and HA/GD is concentrated in a few centers, particularly the UFG, which brings together research groups and consolidated lines of research. UNEB/UESC, UNICENTRO, UFF, and IFRJ also play a significant role, forming a diverse institutional landscape, albeit one marked by regional asymmetries. Other universities, such as UFAC, UFPA, UFRGS, PUC-SP, and UEL, act complementarily, contributing to the strengthening of networks and alliances in the area.

The representativeness of these research projects stems from these institutions' commitment to

diversity and educational inclusion, as evidenced by the continuing education programs promoted by graduate programs. In this context, PPGE/CM/UFG, through LPEQI, stands out for its studies focused on accessibility in Science and Mathematics Education; PPGE/UFF deepens research on educational policies and teacher training; PPGE/UNICENTRO emphasizes inclusion and regional development; PECCEM/UEL promotes interdisciplinary training in Science and Mathematics; the teaching line of PPGQ/UFRGS improves teaching methods and materials; and the programs of UNEB and UESC reinforce continuing education, the appreciation of diversity, and the qualification of pedagogical practices, as shown in Figure 4.

Figure 4. Institutions involved and number of projects



4. Conclusions

This research rigorously and transparently synthesizes the scientific production published between 2019 and 2024 on teacher training in Science (Biology, Physics, and Chemistry) at the interface with Special Education in Brazil, focusing on student with giftedness. The findings indicate that despite the recognition of this population in the National Curriculum Guidelines, weaknesses persist in undergraduate curricula, marked by the absence of consistent training direction. When the topic is addressed, it occurs mainly in elective courses, which

perpetuates training gaps and compromises the ability of teachers to identify and adequately serve students with this profile in public schools. In addition, there is a notable shortage of studies focused on the training of physics teachers, since, in the scope of this research, no publications were identified that addressed this curricular component with the demands of special education.

Furthermore, we agree with Rocha-Oliveira (2019) in stating that supervised practices, although still under-explored, constitute a strategic training space capable of promoting conceptual advances and critical reflections on Special Education. Similarly,

participation in scientific events focused on the subject is relevant for expanding teachers' knowledge, as argued by Adams (2021).

With regard to continuing education, understood as a *fertile locus* for addressing gaps in initial training, the analysis of the studies allows us to infer that in order to broaden understanding of student diversity, strengthen more accessible teaching practices, and encourage critical reflection on teaching practice in science, it is essential to establish markers of professional development in training activities that link special education to the topic addressed here, since, in general, such training has not contributed effectively to the advancement of this field (Souto et al., 2021).

Despite these limitations, we identified opportunities for development that come mainly from teachers and students participating in research in Graduate Programs (PPG) focused on monitoring characteristics and caring for this population, particularly in the Southeast and Midwest regions. Among these initiatives, the following stand out: research experimentation (Nóbrega, 2022); the development of teaching materials to stimulate cognitive, creative, and social skills; the application of the STEAM approach to identify high potential in secondary education (Mateus, 2024; Machado, 2025); individualized remote mentoring (Xavier, 2023); and the use of gamification and active methodologies to strengthen students' autonomy, collaboration, and scientific vocation.

However, these actions are still sporadic and fragmented, lacking greater dissemination, effective collaboration between regular classroom teachers and special education specialists, participation by school administrators, and the establishment of networks to share practices with other institutions, which limits their expansion and consolidation. In addition, there is a clear need to establish parameters capable of identifying institutional gaps between public and private universities, providing support for the design of ethical and evidence-based educational policies (Vasco et al., 2025).

5. Funding: CNPq.

Authors' contribution

Leonora Aparecida Souza dos Santos: conceptualization; data curation; formal analysis; fun-

ding acquisition; investigation; methodology; project management; resources; supervision; visualization; writing—original draft; writing—review and editing.

Lorrana Nara Naves Nóbrega: conceptualization; data curation; formal analysis; investigation; methodology; project management; supervision; visualization; writing—original draft; writing—review and editing.

Cláudio Roberto Machado Benite: conceptualization; funding acquisition; methodology; project management; resources; software; supervision; visualization; writing – review and editing.

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