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Providing Freedom to (Re)learn? What? An Elective Artistic Component in Postgraduate Studies that (Re)humanizes the Individual and Scientific Knowledge

Fornecer Liberdade para (Re)aprender?! O quê?! Uma Componente Eletiva Artística na Pós-Graduação que (Re)humaniza o Ser e o Saber Científico

¿Proporcionar Libertad para (Re)aprender? ¿Qué? Una Asignatura Optativa Artística en el Posgrado que (Re)humaniza el Ser y el Saber Científico

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Abstract

This study[1] is both qualitative and practical in nature and aims to foster a more humanistic and pluralistic understanding of learning and knowledge production in continuing education for teachers interested in the dialogue between the arts and the teaching of science and mathematics. To this end, we used aspects of Carl R. Rogers' educational framework (e.g., liberating and fraternal learning), Natalie Rogers' methodological framework (e.g., use of the arts as a means of expressing feelings and content), and Paul K. Feyerabend's epistemology (e.g., methodological plurality in the production of knowledge), combined with the Design-Based Research approach to design a curricular component offered in the elective course of the Graduate Program in Science Education and Teacher Training at the State University of Southwest Bahia. Implemented in the second semester of 2024, the curricular component 'Interfaces between science and art' had its data collected from aspects of ethnographic observation and analyzed in light of constructivist grounded theory. As a result, a theory emerged that legitimizes the feasibility of promoting freedom to learn in Brazilian graduate programs by enabling the artistic expression of scientific and mathematical knowledge through projects designed for basic education — reverberating, beyond the academic context, more humane and pluralistic perspectives for teaching and (re)learning science and mathematics.

Keywords: elective curriculum component, postgraduate studies, plurality and freedom in learning, artistic expression, teaching science and mathematics

Resumo

Este estudo, de abordagem qualitativa e caráter prático, tem como objetivo construir uma compreensão mais humanista e pluralista dos modos de aprender e de produzir conhecimento, no contexto da formação continuada de docentes interessados(as) na interlocução entre as artes e o ensino de ciências e matemática. Para tanto, mobilizam-se aspectos dos referenciais educacional de Carl R. Rogers (e.g., aprendizagem libertadora e fraterna), metodológico de Natalie Rogers (e.g., uso das artes como meio de expressão de sentimentos e conteúdos) e epistemológico de Paul K. Feyerabend (e.g., pluralidade metodológica na produção do conhecimento), aliados à abordagem da Design-Based Research, na concepção de uma componente curricular ofertada no núcleo de disciplinas eletivas do Programa de Pós-Graduação em Educação Científica e Formação de Professores, da Universidade Estadual do Sudoeste

1 This work refers to the research carried out during the first author's postdoctoral stage—under the supervision of the second author—which, in turn, emerges as one of the developments of Jorge's doctoral thesis (2022).

da Bahia. Implementada no segundo semestre letivo de 2024, a disciplina 'Interfaces entre ciência e arte' teve seus dados coletados a partir de aspectos da observação etnográfica e analisados à luz da teoria fundamentada construtivista. Como resultado, emergiu uma teorização que legitima a viabilidade de promover a liberdade para aprender na Pós-Graduação brasileira, ao possibilitar a expressividade artística de saberes científico-matemáticos por meio de projetos concebidos para a Educação Básica — reverberando, para além do contexto acadêmico, perspectivas mais humanas e plurais para ensinar e (re)aprender ciências e matemática.

Palavras-chave: componente curricular eletiva, pós-graduação, pluralidade e liberdade em aprender, expressividade artística, ensino de ciências e matemática

Resumen

Este estudio, de enfoque cualitativo y carácter práctico, tiene como objetivo construir una comprensión más humanista y pluralista de las formas de aprender y producir conocimiento, en el contexto de la formación continua de docentes interesados en el diálogo entre las artes y la enseñanza de las ciencias y las matemáticas. Para ello, se movilizan aspectos de los referentes educativo de Carl R. Rogers (por ejemplo, el aprendizaje liberador y fraternal), metodológico de Natalie Rogers (por ejemplo, el uso de las artes como medio de expresión de sentimientos y contenidos) y epistemológico de Paul K. Feyerabend (por ejemplo, pluralidad metodológica en la producción de conocimiento), junto con el enfoque de la investigación basada en el diseño, en la concepción de un componente curricular ofrecido en el núcleo de disciplinas optativas del Programa de Posgrado en Educación Científica y Formación de Profesores de la Universidad Estatal del Sudoeste de Bahía. Implementada en el segundo semestre académico de 2024, la asignatura 'Interfaces entre ciencia y arte' recopiló datos a partir de aspectos de la observación etnográfica y los analizó a la luz de la teoría constructivista fundamentada. Como resultado, surgió una teorización que legitima la viabilidad de promover la libertad para aprender en la educación de posgrado brasileña, al permitir la expresividad artística de los conocimientos científico-matemáticos a través de proyectos concebidos para la educación básica, lo que repercute, más allá del contexto académico, en perspectivas más humanas y plurales para enseñar y (re)aprender ciencias y matemáticas.

Palabras clave: componente curricular optativo, posgrado, pluralidad y libertad en el aprendizaje, expresividad artística, enseñanza de las ciencias y las matemáticas

Con-text (and) (Up)dating: Initial Propositions

"I try to strip myself of what I have learned […]", writes Pessoa (2013, p. 69), "[…] to forget the way of remembering that I was taught, / And scrape the paint with which I was painted, / To unbox my true emotions, / To unwrap myself and be me […]" (p. 69, our translation). A poetizing that considers 'learning to unlearn,' to free the human being from imposed knowledge. Knowledge that makes the subject passive, inexpressive, and automated with formatted, leveled, limited and definitive thoughts. This in a world that reduces to the same the whole that is multifaceted, standardizing the divergent into equivalent and labeling the unquantified (e.g., creativity, imagination, beliefs, etc.) as unreasonable.

However, contrary to 'learning to unlearn'—in the perspective of not undoing or forgetting—it is important to have a basis for the development and flourishing of the being. It is necessary to continuously learn how to learn. (Re)learn, for example, (not only) in education, that scientific knowledge is not thought, formulated and produced in an unproblematic, ahistorical, algorithmic, static, absolute, rigid, unique, and neutral way—alien to subjective assumptions, affective elements, idiosyncratic aspects and the historical context in which it is developed. It consists of multidirectional discussions, multiprocedural perceptions, multicultural insertions, and abnormal speculations. It is necessary, therefore, to (re)liven, in the opposite of compartmentalizations and uniformizations, the human essence, as well as pluralistic, of the process of learning to learn from being and knowledge—linked, essentially, to research in science teaching.

In addition, although science history has given contributions to teaching—highlighted by researchers and present in government recommendations and guidelines in the country—it is essential the construction of an interface that expresses an approximation between educators and historians of science (i.e., between science history and science teaching) for the (re)humanization of knowledge and the being who learns about it, especially in the field of proposals for the classroom. Based on the historical 'long duration' that "[…] encourages research in the great temporal diversity" (Prado, 2020, p. 19, our translation) and the use, within it, of periodization or pieces of history—as the historian Le Goff (2015) calls it—it is feasible to immerse oneself in the "general panel" of the history of science and explore historical segments that are aligned with teaching and/or research objectives.

Based on more general historiographical works of science and art, Jorge and Peduzzi (2022a) broadly exemplify the transformations in the way of perceiving, understanding, and conceiving the world through graphic records and other artistic expressions produced by peoples that extend from the Upper Paleolithic period to the 20th century. Other studies approach specifically: (i) the artistic portrayal of knowledge about nature and the world (e.g., cosmological events) represented/illustrated by archaic peoples (e.g., Mesopotamian, Egyptian, and Chinese) in a period that precedes writing and the Greek investigative inquisition of the 6th century BCE (Jorge & Peduzzi, 2022b); (ii) the conceptions and constructions of the world artistically recorded by the Greek civilization (e.g., archaic, classical, and Hellenistic), from the 6th century BCE, and by Islamic Arabic, until the middle of the 12th century (Jorge & Peduzzi, 2020); (iii) some historical segments of physical science, between the 15th and 18th centuries, with themes—on cosmology, astronomy and physical concepts—that can be expressed from historical correspondences that occurred in visual arts (i.e., through two-dimensional pictorial representations) (Jorge & Santos, 2023); and (iv) certain historical articulations established between artistic productions, referring to the visual arts, and scientific productions, related to physics, developed in the 19th and 20th centuries (Jorge, 2022).

Although historical episodes that intersect since periods prior to writing are evidenced in art (which encompasses, at least, the artistic languages of music, dance, theater and visual arts) and the sciences, they have been expressed, especially in education, as two totally distinct, compartmentalized, and (de)humanized areas of knowledge. It is contrary to a view similar to this, for example, that the arts—labeled merely as something decorative or aesthetic, of an emotional or affective character, with no cognitive or pragmatic value in the theoretical-investigative sphere—are antagonistic to the sciences, that the physicist, actor, opera singer and epistemologist Paul K. Feyerabend (1924–1994) dedicates himself, especially from 1980 onwards, to investigate the approximations between the two fields. In many of his works, such as the book 'Science as art', Feyerabend (2003) gives historical examples full of symbologies and artistic constructions interspersed with exhibitions and scientific narratives.

Silveira et al. (2018) point out some of the multiple expressions that circumscribe the process of interlocution between art and sciences: *Art and Science*, *Art-science*, *Art + Science*, *Art & Science*, *Art/Science*, *Artsci*, *Art-Sci*, *Art/Sci*, *Science-Art*, Sciart, *Science & Art*, among others. Nationally, there are researchers who use, for example, 'ciênciarte', 'arte-ciência', and 'arteciência'. Jorge (2022) uses 'art(sci)cular'[2] to enunciate, in counterpoint to a tendency towards segmentation and Cartesian disposition, that the fields of art and sciences are articulated historical constructs that should not be detached.

This integrative perspective also resonates in the proposal of the therapy of the expressive arts centered on the psychotherapist Natalie Rogers (1928-2015) (N. Rogers, 2011). The proposal emerges from the association between the qualities of her mother Helen M. Rogers (1902–1979), an artist, and her father Carl R. Rogers (1902–1987), a psychologist and educator who transposes client-centered therapy—a person-centered approach—to the classroom, formulating a more humanistic and student-centered theory of meaningful learning. According to the author and collaborators, the term for 'expressive arts'—which can be directed to the education to express both feelings and scientific knowledge—"[…] refers to the use of the emotional and intuitive aspect of ourselves in […] a process of self-discovery through any form of art […]" (N. Rogers et al., 2012, p. 36, our translation).

This reflection can support the (re)thinking teacher training in science or mathematics, since "[…] The processes of continuing education are not conceived from a humanizing perspective, since they are based on practices that do not open space for discussions about subjectivity […] [and] the construction of personal relationships […]" (Dalla Valle et al., 2023, p. 17, our translation). Focusing, then, on the (continuing) training of teachers in the field of science or mathematics and to outline proposals diversified from those traditionally hardened by a linear system of learning and teaching—such as offering a course in the core of elective courses of a Graduate Program

2 Art(sci)cular originates from 'articulate'. In 'articular' (co)exists '*art*'. Between '*art*' and 'i' there is a space in which two elements are circumscribed and inserted: 's' and 'c'. The union of the letters (i.e., 's' + 'c' + 'i') results in the construction of '*sci*'—the abbreviation for *science*.

(PPG), which proposes historical, epistemological, conceptual, scientific, through an 'Expo(r)-(po)sição Art(sci)culada' [Art(sci)culated Exposure proposal in English]—can be a way to restore the efficiency and humanity of the practitioners of this craft, as well as the thematic content itself. This meeting of points allows the activation of the educational framework (e.g., the theory of significant learning by C. Rogers (1978)) adopted in the aforementioned investigation, whose approach is humanistic and the learning developed from a whole, involving and at the same time transcending cognitive, affective, and psychomotor aspects.

Inspired by the work of Jorge and Peduzzi (2022c), who propose a theoretical activity of interlocution between science and art in the light of C. Rogers, N. Rogers and Feyerabend, this study draws its concerns through the following questions: how is an 'Expo(r)-(po)sição Art(sci)culada' implemented—which exposes historical positions, epistemological, educational, scientific, mathematical, artistic and other natures in an articulated way—in an elective course in the Graduate Program in Science Education and Teacher Training (PPG-ECFP), of the State University of Southwest Bahia (UESB)? And what sequels emerge from it to (re)think the process of learning to learn from being and the continuous way of (re)learning about scientific-mathematical knowledge? Questions that are condensed in the general objective of exploring and spreading a more humanistic and pluralistic understanding of the ways of learning and producing knowledge in the continuing education of teachers, interested in the interlocution between art and the teaching of science and mathematics. Something that can be mobilized by the educational references of C. Rogers (e.g., more liberating and fraternal learning), the methodology of N. Rogers (e.g., use of the arts as a means to express feelings and knowledge), and the epistemology of Feyerabend (e.g., methodological diversity in the production of sciences). This is when planning to carry out an elective course in the PPG-ECFP of UESB—intended for master's, doctoral, and special students—that provides the creation of artistic-scientific/mathematical projects designed for Basic Education and their presentation at the Expo(r)-(po)sição Art(sci)culada.

To this end, in this qualitative and practical investigation, the context of the course is initially described—approved by the Research Ethics Committee (CEP) of UESB with a certificate of presentation of ethical appreciation under number 71279123.9.0000.0055—, informing the methodological and structural framework for planning and executing classes under the bias of *Design-Based Research*. Subsequently, this study presents aspects of the collection, carried out through elements of the ethnographic observation of Angrosino (2009), and the analysis of data, in the light of the constructivist grounded theory of Charmaz (2009), followed by the construction of codifications and categorizations that enable the creation of a theorization. Finally, perspectives and frontiers of this study are woven.

Formative In(ter)ventions: The Discipline, the Classes, the Creations, and the Exposure Proposal

The course entitled 'Interfaces between science and art: considerations for science education' (PGSECFJ086) was offered at the core of elective courses of the PPG-ECFP at UESB, Jequié campus, during the second academic semester of 2024. The course had a workload of 30 hours, distributed over 12 Thursdays, between 6 pm and 10 pm, and was taught by the authors of this study. The classes were hybrid; composed of both theoretical and practical activities as well as online and face-to-face activities (Figure 1). Nine students from[3] the areas of chemistry, biology, and pedagogy participated in it; three regular students from the master's course, three from the doctoral course, and three special students—who attended the course as isolated—interested in the thematic area. *Google Classroom* was used to organize the course and guide the studies, especially regarding the availability of materials, proposition, and orientation of activities.

Figure 1

Schedule of the elective course 'Interfaces'

CRONOGRAMA DAS AULAS PARA A DISCIPLINA ELETIVA

INTERFACES ENTRE CIÊNCIA E ARTE: CONSIDERAÇÕES PARA A EDUCAÇÃO CIENTÍFICA

(PPG-ECFP/UESB-2024/2-30H)

DATES/DAYS (THURSDAY)	HOUR	CLASSES
(1) 08/08/2024	7 PM TO 9 PM	1ST CLASS (ONLINE) -2 H PER CLASS
(2) 22/08/2024	6 PM TO 10 PM	2ND AND 3RD CLASSES (IN-PERSON) - 4 H PER CLASS
(3) 29/08/2024	7 PM TO 9 PM	4TH CLASS (IN-PERSON) - 2 H PER CLASS
(4) 05/09/2024 (5) 12/09/2024 (6) 19/09/2024 (7) 26/09/2024	PROJECT DEVELOPMENT	5TH, 6TH, 7TH, AND 8TH CLASSES (PERIOD WITHOUT IN-PERSON CLASSES) - 8 H PER CLASS
(8) 03/10/2024	7 PM TO 9 PM	9TH CLASS (IN-PERSON) - 2 H PER CLASS
(9) 10/10/2024	6 PM TO 10 PM	10TH AND 11TH CLASSES (IN-PERSON) - 4 H PER CLASS
(10) 17/10/2024	7 PM TO 9 PM	12TH CLASS (ONLINE) - 2 H PER CLASS
(11) 07/11/2024	6 PM TO 10 PM	13TH AND 14TH CLASSES (IN-PERSON) - 4 H PER CLASS
(12) 14/11/2024	7 PM TO 9 PM	15TH CLASS (ONLINE) - 2 H PER CLASS

Source: Prepared by the authors.

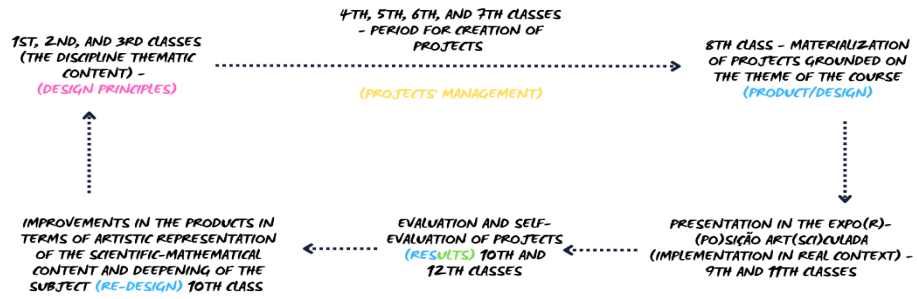
Design-Based Research (DBR) was used as a methodological structuring to develop and implement the course's 12 days of classes. The DBR methodology, originally used to improve the *design process*, can be explored in a situation whose objective is to apply some principle related to a theoretical dimension of knowledge in the classroom (Mesquita et al., 2021).

3 The nine students are subsequently identified by means of alphanumeric coding (09 Students = D1 to D9). Similarly, projects are also named P1, P2, etc.

In this case (Figure 2), DBR was mobilized when texts were made available to students, such as those by Jorge and Peduzzi (2020; 2022b), Jorge (2022), and Jorge and Santos (2023), which exemplified the transformations in the ways of perceiving, understanding, and conceiving the world (scientific-mathematical) through artistic records produced in some historical periods between the Upper Paleolithic and the 20th century. This thematic content was conceptualized as 'design principles' (i.e., epistemological premises about the subject to be studied). By discussing and (re)learning about this set of theoretical knowledge, within the classroom, it was possible for the students to (re)use it to create—or, rather, to *design*—some product or artistic project based on the theme of the discipline. The 'process' of developing this product was guided by several resources (e.g., such as reports, oral presentations, among others) that helped to analyze the progress (or not) of the *design*. Once finished, the project was presented, at first, in the classroom. After the presentation, the student self-evaluated it and it was also evaluated based on the perception of classmates and the professors responsible for the discipline. These evaluations gave raise to improvements that could be made in the products in terms of the artistic representativeness of the scientific-mathematical content and the deepening of the subject—enabling a new (re)application of the projects outside the classroom, in an 'Expo(r)-(po)sição Art(sci)culada,' open to the public.

Figure 2

Scheme representing the DBR methodological structuring in the classes planning



Source: Prepared by the authors.

This continuous and improvement mechanism helped the (re)design of the product and of the individual who produced it—issues that were aligned with the educational-Rogerian and epistemological-Feyerabendian perspectives of research on beings and knowledge that are in constant development.

(In)discipline in Construction: Classes in the Process of Implementation

The 1st remote class[4] included the presentation of the faculty and students, the teaching plan, and a brief expository-dialogued seminar on the course. On this occasion, the nine students were notified about the main activity of the course, in which each one would have to choose a historical segment or theme between the Upper Paleolithic and the 20th century, according to their interest, to portray the relations between science/mathematics and art. Subsequently, the student should deepen the debate around the chosen episode, with the purpose of reinventing it and expressing it in the artistic language they considered most appropriate to represent it (e.g., through music, literature, dramaturgy, cinematography, painting, etc.). The artistic-scientific/mathematical projects, conceived with a view to future application or adaptation in Basic Education, would be presented, at the end of the course, at the 'Expo(r)-(po)sição Art(sci)culada', an internal event open to the public.

The students were also informed that, if they felt uncomfortable with the proposed activity, they could, alternatively, prepare an essay-argumentative text. This means that, when seeking to promote freedom in the classroom through self-initiated learning—driven by internal motivation, genuine interest, curiosity and emotional involvement with the content—and self-directed learning—in which the student leads and takes responsibility for the learning process itself,—it is equally necessary to recognize the legitimacy of refusing this freedom. As C. Rogers (1978) ponders: "It does not seem reasonable to impose freedom on those who do not want it" (p. 137, our translation), referring to those who prefer a more guided and programmed learning model. In view of this, students were asked to reflect on ideas for possible projects or text productions for the next classes.

Based on the previous readings carried out by the students, the texts by Jorge and Peduzzi (2022b; 2020) were discussed in the 2nd and 3rd face-to-face classes through expository-dialogued seminars. The thematic content encompassed analyses of the transformations in the ways of perceiving and conceiving the world, from the cosmo-pictorial perspective of peoples prior to writing (e.g., such as those of the Upper Paleolithic) and others later (e.g., such as Mesopotamian, Egyptian, Chinese, Greek, and Islamic Arabic), until the 12th century. Through these classes it was possible to mobilize the concepts of practical relativism, which values different forms of knowledge according to its adequation to specific historical and cultural contexts, and democratic—which defends the right of different forms of knowledge coexisting—as proposed by Feyerabend (1977). Both concepts converged on the reflection of methodological pluralism, which rejects the hegemony of a universal Western rationality in favor of multiple interpretive and epistemological approaches.

4 The lessons, which include slids and other activities, are available on the multidisciplinary open-access repository Zenodo. Jorge, L., & Santos, B. F. (2026). Aulas para a disciplina Interfaces entre ciência e arte. *Zenodo*. https://doi.org/10.5281/zenodo.20475222

Apart from this, although the focus was the area of physics, historical insertions of art with the fields of chemistry and biology were also carried out in these classes within the aforementioned period. An integrative proposal for these areas involved the production of organic and natural watercolor paint (Figure 3), based on acid-base reactions with red cabbage—by adding different amounts of sodium bicarbonate (alkaline) and lemon juice (acid)—in order to obtain different colors between greenish or bluish and pinkish or reddish to use them to create paintings inspired by cave records that represented cosmic events (e.g., such as eclipses, constellations, comets and the sun). A solvent (water) was also used to dissolve the pigment extracted from the saffron, obtaining a yellowish dye.

Figure 3

Activity with organic and natural watercolor paint

Source: Personal archive of the author of this study.

Throughout the 2nd and 3rd classes, examples of projects focused on Basic Education were presented, by which students could be inspired to materialize the relationships between science/mathematics and art in the historical segment or chosen theme.

The 4th face-to-face class began by reviewing the historical milestone discussed above, through a large group question and answer game. Then, an expository-dialogued seminar was held, based on the texts of Jorge (2022) and Jorge and Santos (2023), which the students read previously. The thematic content addressed transformations in the way of thinking and doing science, expressed by art, from the 13th to the 20th century, with an emphasis on biology and chemistry—and with insertions of physics and mathematics. At the end of the class (the last theoretical one), the students were more inclined to elaborate artistic-scientific projects to the detriment of text production. Two pairs were formed and five students chose to develop their projects individually. Part of the group had already consolidated their proposals, while others were still reflecting on what to develop.

There were no face-to-face or remote meetings in the 5th, 6th, 7th, and 8th classes. This period was reserved for the development of projects or text productions, with emphasis on self-initiated and self-directed learning, according to the Rogerian approach. The professors were considered flexible resources, available to the students, intervening only when requested to offer support, guidance or materials.

The 9th face-to-face class was dedicated to the final adjustments of the projects or texts and to the preparations for the 'Expo(r)-(po)sição Art(sci)culada', both internal and external, planned for the following classes. However, only four of the projects outlined in the first theoretical classes (i.e., D1, D2, the D3-D4 pair and the D5-D6 pair) were presented in the internal exhibition. One of them, that of the D3-D4 pair, needed re-elaboration. D7 had not defined the content (historical segment or theme), nor the artistic language. D8 was absent, and D9 was halfway through the project development. Given these pending issues, it was decided that the 10th class, initially planned as remote, would be held in person, in order to enable the presentation of the remaining three projects and the repreparation of one of them.

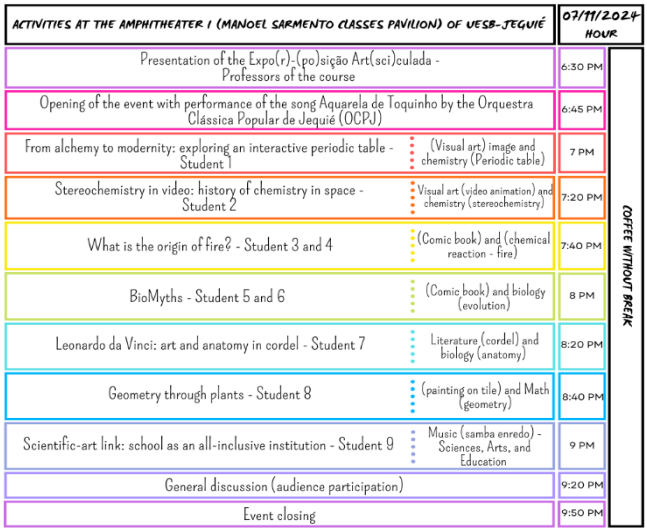
In the 11th face-to-face class, the 'Expo(r)-(po)sição Art(sci)culada' was held, open to the local and university public, with the presentation of the seven projects—based on the expressive arts of N. Rogers. Finally, in the 12th class, the evaluation process was conducted collaboratively—with the participation of colleagues and teachers. This moment was mediated by two reflective devices — 'Invitation to (re)think self-evaluation' and 'Invitation to look at evaluate' — which guided the critical analysis of the initiatives, choices, procedures, and strategies adopted by each student to achieve (or not) the objectives set individually and those proposed by the course.

Exhibition of the 'Expo(r)-(po)sição Art(sci)culada'

The seven projects, materialized in the form of a literary writing (e.g., a *cordel* about Leonardo da Vinci's anatomy), a song (e.g., a *samba enredo* about art, science, and education), paintings (e.g., use of paints on tiles to express geometry in plants), a video (e.g., a video-animation about the history of stereochemistry) and drawings correlated to plots (e.g., an interactive periodic table; a comic book (comic) about chemical reactions and another about Darwinian evolution), composed the 'Expo(r)-(po)sição Art(sci) culada' (Figure 4).

Figure 4

Programming of the 'Expo(r)-(po)sição Art(sci)culada' hosted by the discipline 'Interfaces'



Source: Prepared by the authors.

The 'Expo(r)-(po)sição Art(sci)culada', which articulated arts, sciences, and mathematics through the traditional presentation (i.e., through an exhibition of positions) of the projects and/or a booth (i.e., as an exhibition) dedicated to them, featured the performance of the Popular Classical Orchestra of Jequié (OCPJ)—a non-profit entity that develops a work of human formation for children and young people from peripheral neighborhoods of Jequié, in Bahia, and region—which performed the song 'Aquarela' by Toquinho. The intention was to discolor the way of seeing scientific-mathematical knowledge, in the sense of already having awareness or knowledge about it, in order to (re)color it under a more creative and human bias.

The Creations at the 'Expo(r)-(po)sição Art(sci)culada'

In the correlation between knowledge discussed in the course 'Interfaces' [e.g., the painting 'The alchemist in search of the philosopher's stone discovers the match' (1771) by Joseph Wright (1734-1797) debated in the 4th class] and the previous knowledge built about alchemy—in a course that he took in the degree on the history of chemistry—, the master's student D1 focused on artistic representations or alchemical graphic symbologies in order to establish links between them and the chemical elements when building a dynamic and interactive periodic table (PT). To this end, he explored the historical chemical context alongside the artistic one through the symbols of alchemy cataloged by the Federal Council of Chemistry (CFQ) and papers published in the 'Chemical element' section of the journal 'Química nova na escola'.

The interactive PT (Figure 5) was developed on the *Genially* platform—to make it easy for other teachers to use and access the material. D1 also used *Canva* to create visual arts (i.e., images in general, such as photographs, portraits, paintings, drawings, etc.) that expressed correspondences to chemical elements, aiming to include them in the periodic table. D1 reported that, although "[…] in the beginning it was worrying how to start it", he intends to finish the project "[…]—which is something I didn't get [in the discipline], I lacked breath. But who knows, maybe in the future I will be able to conclude and make the material 100% complete with the 216 [chemical] elements […]" (D1).

Figure 5

Dynamic and interactive periodic table

Source: Personal archive of the author of this study.

During the project's presentation at the 'Expo(r)-(po)sição Art(sci)culada,' open to the public, D1 distributed bookmarks with information about the interactive PT. Each marker (Figure 5) had a number: two of them were drawn and people were invited to choose a chemical element from the periodic table, which was arranged on the stage of the amphitheater, for D1 to explain its historical context and its association with the artistic sphere. The interactive PT, in addition to being able to be used, as D1 states, in the "[…] future, in my own classroom practice […]", can be worked on in the 9th grade of Elementary School, High School, Higher Education, and Graduate Studies [e.g., in the training of teachers and chemists]. In Elementary Education, for example, it can be implemented individually or as a component of some didactic sequence, depending on the context of its application and objectives, for the historical-epistemological and conceptual discussion related to the construction of the periodic table, especially by rescuing alchemical knowledge supported by artistic representation, to (re)humanize chemistry—regarding the ways of learning and teaching.

The project of D2, a graduate in chemistry and a master's student, emerged from a theme that has accompanied her since graduation and that she continues to explore in her dissertation: the complexity and abstract nature of content related to stereochemistry—since it demands the visualization of molecular structures in space (three-dimensional). Based on Eduardo Fleury Mortimer's study of multimodality, in which he uses various semiotic modes and resources to communicate content (i.e., a

communication that goes beyond spoken or written words, which encompasses images, gestures, symbols, graphs, diagrams and other forms of non-verbal and visual language), D2 chose to portray artistically and briefly the history of stereochemistry through a video-animation—which combines sound elements, visuals, writings, etc. D2 wrote a text about the history of stereochemistry and submitted it to the *ElevenLabs* platform to convert it into audio—into a spoken narrative. She also used *Canva* to create images and *GIFs*—added to narration to assist in the artistic and three-dimensional visualization of molecules. After these processes, she inserted the audiovisual elements into the *Movavi Video* platform for integration and elaboration of a video-animation of approximately five minutes (Figure 6). D2 mentioned that "[…] Working on video-animation was quite a journey, it was challenging for me", but "[…] made me very proud" (D2).

Figure 6

Video animation on stereochemistry

Source: Personal archive of the author of this study.

At the end of the presentation of her project at the 'Expo(r)-(po)sição Art(sci) culada', D2 raffled off to the public some bags with molecular structures made with jellybeans (Figure 6) and found in everyday life (e.g., lactic acid, adrenaline, vitamin C, and leucine). D2's project was initially designed for the undergraduate program—being later applied in the chemistry degree course at UESB as a unit of the didactic activity that was proposed in her master's research. However, video-animation can also be intended for Basic Education in the perspective of being inserted as a didactic and dynamic resource, which articulates historical, epistemological, conceptual, scientific, and artistic aspects for introducing the study related to stereochemistry, in the scope of organic chemistry. In addition, the project can be shared on a video-sharing platform to promote equity in access to scientific information, especially chemistry, under a more human and multidiverse bias.

D3 (special student) and D4 (master's student), also from the area of chemistry, investigated the theme related to chemical reactions—as it is difficult to abstract from in high school and it is sometimes present in entrance exams and in the National High School Exam (Enem). They chose to produce a comic book because it makes it possible to expand the understanding of concepts, the promotion of better discussions about certain definitions and because it is a viable means of pictorially and artistically expressing conceptions about chemical reactions.

From different readings, D3 and D4 set up a plot in which potassium permanganate, personified by the character Pepo, and glycerin, represented by Gli, come into contact—romantically embracing each other—and generate a combustion reaction with fire (Figure 7) that is represented in an artistic way and not in the fetishization of the equation of a chemical reaction. They used *Canva* for the artistic part of the comic (e.g., the creation of paintings, speech bubbles, written text, the scenery, the characters, etc.). About the process of the project's development, D4 reports that "[…] it was a lot of work […]", and D3 points out that "[…] I don't have many skills focused on the issue of art and, thus, I struggled, but I liked it because in the end the product was very good".

Figure 7

Comic book script staging about chemical reactions

Source: Personal archive of the author of this study.

During the project's presentation at the 'Expo(r)-(po)sição Art(sci)culada', D3 and D4 opted for the dramatization of the script; that is, by staging the comic with three high school students from a public school in the region of Jequié. During the students' performance, there was an experimental demonstration of the chemical reaction between potassium permanganate and glycerin—simple and easily accessible materials. D3 informs that the students of the dramatization requested to carry out "[…] this activity in the school, in the plural and scientific exhibition of the school, because it is an activity that […] spends little and at the same time […] manages to involve science and art […]". In addition to the possibility of D3 and D4's comics being considered as a didactic material that can be inserted in studies on chemical reactions, especially in high school, it can be shared with other teachers and the general public, seeking to (re) humanize the ways of communicating and teaching this chemical content.

Based on epistemological debates linked to the proficiency of the interlocutions between art and sciences formulated by Gaston Bachelard and considering that D5's thesis proposal covers issues related to *science, technology, engineering, arts and mathematics* (STEAM), D5 and D6, the first graduated in biology and the latter a doctoral student, focused on the potential of exploring scientific-biological knowledge through a sequential art with a more oriental style. D5 and D6 chose the content linked to evolution as a theme for the comic as way to demystify the fact that it encompasses a process of constant improvement that always leads to perfection. The comic was created through the *AI Comic Factory*, in the *Hugging Face Space platform*, which makes it possible to create comics by inserting *prompts* related to the investigated theme in its interface. The

plot was produced with the help of *ChatGPT,* revised with support in the literature and improved by D5 and D6. The combination of the script and the images were integrated into *Canva*; a process that led to the materialization of the comic (Figure 8). It is worth mentioning that D5 and D6 tested several platforms and *prompts* for generating the arts in comics, faced limitations regarding the use of some resources and in learning them, but they overcame the difficulties and finished the project.

Figure 8

Comic book about Darwinian evolution

Source: Personal archive of the author of this study.

At the end of the project's presentation at 'Expo(r)-(po)sição Art(sci)culada', D6—D5 was at an external event—distributed copies of the comic to the audience. On this issue of distribution, D6 reported that "[…] I've even taken copies of the comic book to work at the school […]". The project, then, can be explored in elementary, secondary, and higher education classes to (re)humanize, in the light of the intertwining with visual art, biology taken from a more technicist perspective.

The project of D7, who has a degree in pedagogy and is a doctoral student, was to develop a *cordel* involving Leonardo da Vinci. D7 pointed out that his interest in Leonardo emerged through discussions raised—in the 4th class of the course—in the introduction to Isaacson's book (2017). In it, the author (re)humanizes Leonardo by informing that: he was an illegitimate son, gay, vegetarian, left-handed, very smart and, at times, heretical; that he did not go to school and could barely read Latin or do a division calculation; that he was curious and a constant observer; that he had a fertile imagination; that he was neither disciplined nor diligent, among many other aspects. In view of this, D7 focused on the theme related to anatomy, explored by Leonardo through drawings/illustrations of the human body, and used literature in the form of *cordel*—popular in Brazil's northeast—as an artistic way to express this knowledge. The text of the *cordel* was written based on the work of Isaacson (2017). ChatGPT was used to generate a woodcut that pictorially represented Leonardo da Vinci and/or his works on anatomy, such as the Vitruvian man. D7 used *Canva* as a creative support to integrate the text and the woodcut in the form of a string (Figure 9). Regarding the non-directive creation of the project, D7 highlighted that "when we jump our hands to produce, we have difficulty in producing, […] But we participate more and engage better in the teaching and learning process".

Figure 9

Literature in the form of a cordel about Leonardo da Vinci

Source: Personal archive of the author of this study.

The D7 string can be used in elementary and high school, in science and biology classes, for example, with the necessary adaptations at each year and stage. In addition, D7 ponders that: "I, as a pedagogical coordinator, today I can see many perspectives to guide my teachers, especially in the area of natural sciences, to seek this relationship with art […]".

D8, a special student with a degree in pedagogy, pointed out that geometry is a difficult content to understand, especially for elementary school children (early years), so she focused on the beauty and geometric richness present in nature, especially in plants (e.g., flowers exhibit radial symmetry, with petals organized in geometric patterns; the cross-section of the stems often reveals geometric structures, such as circles and polygons, etc.). To express mathematical knowledge from an artistic perspective, D8—who likes to make handicrafts and use recyclable materials—was inspired by the Brazilian painter, engraver, collagist, illustrator, and teacher Beatriz Milhazes, whose works are characterized by the use of color, geometric structures, florals, etc., and made paintings (with gouache paint) in cutouts and segments of tiles that portrayed geometry in plants (Figure 10).

Figure 10

Geometry in floor plans brushed on tiles

Source: Personal archive of the author of this study.

D8's artistic productions, which made up her project, were exhibited at the 'Expo(r)-(po)sição Art(sci)culada' and raffled off to the public at the end. Painting on tiles, in addition to being an activity of representation and artistic expression, can captivate the attention of children in elementary school and allow them to have a greater understanding of geometry.

Drawing on his experiences, D9—a special student with a background in pedagogy—explained that the choice for music as an artistic way to express the knowledge of his project originated from when he witnessed, at the festival of the school in which he first worked, a battle of MCs between students. He then conjectured that the artistic stage can empower, validate, impact, and assist in the rescue of lives. Thus, D9 created the lyrics, rhythm, and melody of a *samba enredo* (Figure 11)—like that of a samba school—of approximately seven minutes, which cradled the entire period of the history of humanity (e.g., how human beings faced art as a condition and expression inherent to their need to externalize the perceptions they had about the world; how the relationship between art and the sciences became closer, separated and, later, was (re)found; and how the school reframed this intertwining)—questions that synthesized some of the discussions facilitated in the classes of 'Interfaces'. Regarding the project's production process, D9 highlighted that "[…] provided the kind of challenge that […] I needed." He also added: "I need this absence—of distance—of structure to flow better. And that's [something] mine. I felt very good" (D9).

Figure 11

Excerpt from the samba enredo

Source: Personal archive of the author of this study.

D9 then performed the *samba enredo* with the ukulele at the 'Expo(r)-(po)sição Art(sci)culada,' open to the public (Figure 11). The music produced can be worked on in the Basic Education classroom, at different levels, by teachers from the fields of history, arts, Portuguese language, and sciences, for example.

(Re)gather and (Re)signifying Data

Telling about pictorial elements of a table. The oralization of a video-animation. Narrate sequenced drawings. Recite a rhyming and illustrated text. Talk about shapes and structures in paintings. Recite the words of a song. Actions recorded in photos, audios, and videos that led to the transcripts and descriptions in the previous section. Only

four of the eight days of class were filmed, the others being intended for developing the projects—in which there was no face-to-face or remote class—(because they included, between the 9th and 14th classes, the presentations of the projects) made up the dataset of this study. These data was collected by the teachers of the course 'Interfaces' through aspects of Angrosino's (2009) ethnographic observation: by establishing oneself between a 'participant-as-observer'—almost integrated into the life of the group, but aware of their activities as a researcher—and a 'fully involved participant'—naturalized in the scenario, with almost faded and unidentifiable tasks.

The data was analyzed based on the Constructivist Grounded Theory (CGT) of Charmaz (2009). The CGT "[…] encourages the researcher to theorize in the interpretative tradition" (Charmaz, 2009, p. 199, our translation). Therefore, with the data, we did not seek to affirm, reinforce or corroborate preexisting theories or preconceived ideas. The objective was to construct a new theorization that emerges from a specific (grounded) context of investigation. This point was characterized as a significant differential for using CGT to the detriment of other approaches that already provide *a priori* theorizations and/or categorizations of what can be hypothetically found from data analysis.

Charmaz (2009) considered "[…] the methods of grounded theory as a set of principles and practices, not as ready-made packages or prescriptions" (p. 24, our translation). She pointed out that there are "[…] flexible guidelines, and [there are] no […] rules, recipes and methodological requirements" (Charmaz, 2009, p. 24, our translation)—something that reverberates in perceptions analogous to those of Feyerabend's (1977) methodological plurality and C. Rogers' (1978) non-directive learning. Due to this, the theorization process has been composed of several non-linear steps. In one of them, with the transcribed data, fragments, excerpts, and clippings of interest and relevance to the research are selected, aiming to express these 'initial codes' in an 'initial coding' that reflects the action—using the gerund, showing that the research is continuous. Along with this stage, texts are elaborated, called 'memoranda', which helps to think about which 'initial codes' have the potential to be grouped, giving rise to provisional categories. This descriptive phase mobilizes the development of another analytical: that of 'focused coding'—the moment in which the groups of 'initial codes', agglutinated according to the similarities of their information, are organized, integrated, refined, and interpreted at a more abstract level in order to raise the categories from provisional to definitive. The final categories are also expressed in a 'focused coding' that reflects action. Following the stages of codification, writing of memos, and a *posteriori categorization*, there is the 'classification' phase, in which the definitive categories are theoretically integrated and compared. This is to carry out the 'writing of the manuscript', the final part of the research, in which a brief tear is made of the course of the investigation from the collection to the interpretation of the data at a more abstract level, alongside the literature, to express the enunciation of a substantive theory—of a local and informal theorization made within the scope of this work, for example—that is, of a grounded theory that is built from mediating and integrating all categories and that helps to answer the research problem(s).

Starting from the description and writing of memorandums made in the previous section, 'Formative in(ter)ventions: the discipline, the classes, the creations, and the expo(r)-(po)sições', the following two subsections were developed: (i) codifications and categorizations and (ii) interpretation and writing of the final manuscript (phase in which the theory was built, based on the mediation of the categories as a more comprehensive whole of the analysis).

Encodings and Categorizations

A favorable scenario for the codifications and categorizations of the exposed data was built from the descriptions of the classes, the projects, and their presentations at the 'Expo(r)-(po)sição Art(sci)culada'. Figures 12 and 18 present the most frequent and relevant 'initial codes', according to the objective of this study, with the seven projects created in the course 'Interfaces'. These codes were expressed in 'initial codings' through actions that indicate continuity (of the analysis).

Figure 12

Initial Encodings for Project 1 (P1) of D1

Sample	Initial encodings
P1 of D1	Linking alchemy concepts with chemical elements and the periodic table. (1)[5]
	Exploring historical-epistemological aspects between alchemy and the periodic table. (2)
	Rescuing graphic symbols of alchemy to (re)humanize the teaching of chemistry. (3)
	Building an interactive periodic table—as a project—for basic education, which can be used in Higher Education and Graduate Studies [e.g., in the training of teachers and chemists], by historically intertwining visual art and chemistry. (4)
	Proposing the individual implementation of the periodic table or as a component of a didactic sequence in chemistry classes. (5)
	Facilitating access to the periodic table, for use by other teachers. (6)
	Reporting difficulty in starting the project and contentment in materializing it. (7)

5 Each initial coding was represented by a reference number.

Figure 13

Initial Encodings for Project 2 (P2) of D2

Sample	Initial encodings
P2 of D2	(Re)humanizing stereochemistry through historical-epistemological and conceptual debates. (8)
	Portraying the history of stereochemistry through video-animation—as a project—which encompasses sound, visual, written elements, etc., in the perspective of diversifying the ways of understanding and learning about the theme. (9)
	Promoting video-animation as a didactic and dynamic resource for basic education, which articulates historical, epistemological, conceptual, scientific, and artistic aspects. (10)
	Directing the implementation of video-animation—individually or as a component of a didactic activity—in courses (not only) in the area of chemistry. (11)
	Enabling the (re)applicability of video-animation by other teachers. (12)
	Making the project open to public on a video-sharing platform to promote equity in access to scientific-chemical information, especially stereochemistry. (13)
	Feeling proud of finishing the proposed challenge of creating a project. (14)

Figure 14

Initial Encodings for Project 3 (P3) of D3 and D4

Sample	Initial encodings
P3 of D3 and D4	Bringing the Greek mythology linked to the fire of Prometheus to introduce the conceptual discussion about the chemical reaction between potassium permanganate and glycerin. (15)
	Producing a comic book—as a project—to expand the understanding of concepts, based on the artistic expression of chemical reactions. (16)
	Expressing chemical reactions through sequential art, using imagery and written text, for basic education, (re)humanizing the ways of communicating and teaching the theme. (17)
	Staging the comic book's plot as a way to involve high school students in a more active and participatory learning process. (18)
	Sharing the didactic material—the project—with other teachers. (19)
	Spreading the comic to the general public. (20)
	Pointing out the difficulty in exercising artistic skills and that the process of developing the project was laborious but rewarding. (21)

Figure 15

Initial Encodings for Project 4 (P4) of D5 and D6

Sample	Initial encodings
P4 of D5 and D6	Choosing the thematic content linked to evolution to demystify, through historical and conceptual discussions, the issue of it encompassing a process of constant improvement that always leads to perfection. (22)
	Exploring scientific-biological knowledge through sequential art with oriental style. (23)
	Elaborating a comic—as a project—to stimulate discussion about misconceptions about evolution, aiming to (re)humanize biology through visual art. (24)
	Informing that the comic book can be worked on in Elementary, High School and Higher Education classes as an introductory component to discuss the theme. (25)
	Enabling the sharing of the comic with teachers and the non-specialized public. (26)
	Testing several platforms and different *prompts* for generating arts in comics and facing limitations regarding the use of some resources. (27)
	Considering the proposal regarding the elaboration of innovative and motivating projects. (28)

Figure 16

Initial Encodings for Project 5 (P5) of D7

Sample	Initial encodings
P5 of D7	Developing interest in Leonardo da Vinci because he is a figure with whom it is possible to exemplify historically the relations between the arts, sciences, and mathematics. (29)
	Focusing on the theme related to anatomy, explored by Leonardo through drawings/illustrations of the human body, and using literature in the form of cordel—the project—as an artistic way to express the mentioned knowledge. (30)
	Bringing the arts to dialogue with scientific knowledge to facilitate the teaching and learning process under a more human bias. (31)
	Using the cordel in science and biology classes in elementary and high school. (32)
	Visualizing perspectives to guide teachers in natural sciences to seek relationships with the arts in their classes and/or in proposing didactic activities. (33)
	Presenting difficulty in producing the project and, on the other hand, engaging more effectively and meaningfully in the process. (34)

Figure 17

Initial Encodings for Project 6 (P6) of D8

Sample	Initial encodings
P6 of D8	Exposing historical and current examples that relate geometry and art. (35)
	Studying concepts related to geometry present in nature. (36)
	Looking at the beauty and geometric richness in plants. (37)
	Representing mathematical knowledge through paintings (with gouache paint) in cutouts and segments of tiles that portray geometry in plants (the course's project)—based on a more playful and human approach to teaching and learning. (38)
	Proposing the activity of representation and artistic expression, through painting on tiles, as a way to captivate the attention of children in elementary school (early years) and allow them to have a greater understanding of geometry. (39)
	Enabling the idea of building an exhibition to share artistic works, on geometry in plants, which children can make. (40)
	Intertwining his artistic preferences (i.e., *hobby*) with the project's development. (41)

Figure 18

Initial Encodings for Project 7 (P7) of D9

Sample	Initial encodings
P7 of D9	Narrating about the history of humanity, from the first artistic representations of nature in prehistory to the expressions of relations between art and science in school. (42)
	Choosing music as an artistic way to express the knowledge of his project. (43)
	Speculating that the artistic stage can empower and validate lives. (44)
	Creating the lyrics, rhythm, and melody of a *samba enredo*—as a project—that articulates the entire period of the history of humanity—regarding the historical construction of the relations between art and science, as well as its expressiveness in education. (45)
	Working music in the basic education classroom, at different levels, by teachers from the fields of history, arts, Portuguese language, and sciences. (46)
	Declaring the song as a way to philosophically discuss the lyrics. (47)
	Showing contentment in developing the project in the light of the absence of directions. (48)

With the expression of the 'initial codifications', their agglutinations were carried out concomitantly by means of similar information. This was done with the aim of grouping for the construction of (provisional) categories based on the creation of 'focused codifications' also made explicit in the gerund (Figure 19).

Figure 19

Elaboration of provisional categories originating from the grouping of initial codifications

Initial encodings (reference numbers)	Focused encodings (provisional categories)
1, 2, 8, 15, 22, 29, 35, 36, 37 and 42	Discussing historical-epistemological and conceptual aspects of the areas of chemistry, biology, and mathematics entangled in the field, and in the light of the context of the arts. (49)
3, 4, 9, 10, 16, 17, 23, 24, 30, 31, 38, 43, 44 and 45	Materializing historical inter-(en)twining of the arts, sciences, and mathematics through projects, aiming to pluridiversify, from non-directive, more dynamic, creative and human approaches, the ways of thinking, questioning, expressing, representing, communicating, teaching, understanding, and (re)learning about scientific/mathematical content, correlated to the artistic field, in basic education. (50)
5, 11, 12, 18, 19, 25, 32, 39 and 46	Exemplifying the possibility of (re)applicability or adaptability of projects by teachers in history, arts, sciences, biology, chemistry, and mathematics in elementary and high school classes, which can be extended to higher education and graduate studies, as didactic and introductory resources/materials to study contents and/or as components of didactic sequences. (51)
6, 13, 20, 26, 33, 40 and 47	Communicating and sharing projects (e.g., through science/mathematics fairs, social networks, papers presented at events, journals, etc.) to promote equity in access to academic production and the (re)humanization of this knowledge. (52)
7, 14, 21, 27, 28, 34, 41 and 48	Enabling self-initiated and self-directed learning through the painful but motivating and rewarding challenge of developing artistic projects that express content or historical episodes related to science and mathematics, in the context of an elective Graduate course, intended for basic education. (53)

To help raise the categories from provisional to definitive, comparisons were made between them in order to create a new grouping for the final establishment of categories—presented at a higher level of abstraction in Figure 20.

Figure 20

Composition of definitive categories in the light of the affluence of focused codifications

Provisional categories (reference numbers)	Ultimate Categories
49, 50 and 53	(Re)humanizing and pluridiversifying the scientific-mathematical production interwoven with artistic expressiveness—in accordance with historical-epistemological and conceptual debates—through projects aimed at basic education, in the 'Expo(r)-(po)sição Art(sci)culada' that is based on the course 'Interfaces'—less rigid and non-directive—of the Graduate Program. (54)
51 and 52	(Re)application and adaptation of projects, in basic education classroom and in other scenarios, as didactic and introductory resources/materials for studying historical, artistic, scientific, and mathematical contents and/or as components of didactic sequences, to (re)humanize the being who (re)learns, in a different way, whether student or teacher, about science and mathematics. (55)

By establishing the definitive categories, a theorization circumscribed by the information codified until then emerged, through the mediation between them. In other words, it means that integrating the codifications (i.e., initial and focused) resulted in a single category that expresses the enunciation of a substantive theory, that is, a theory based on the specific data of this research (Figure 21).

Figure 21

Enunciation of the theorization that emerged from the definitive categories

Ultimate Categories (reference numbers)	Grounded theory (main category)
54 and 55	Plural, historical-epistemological, and conceptual discussions of science and mathematics entangled with the arts and expressed in projects, created in an elective, less rigid, and non-directive course of the Graduate Program to be presented in the 'Expo(r)-(po)sição Art(sci)culada', (re)humanize the process of learning to learn from being and (re)learning about scientific-mathematical knowledge, both in formal spaces, at various educational levels, and in non-formal contexts.

Dialogues in Triangula(c)tion in Theorizing

Among the different statements that made up the substantive theory, the inter-(en)twining of scientific-mathematical production with artistic production was highlighted as a way to subvert the rigidity, segmentation, and compartmentalization of these areas, promoting a more integrated and sensitive teaching. In this scenario, the arts have been configured as a form of expression that can bring to light emotional and affective dimensions, often neglected in the educational and traditional spheres, especially in studies related to science and mathematics. The expressive arts explored by N. Rogers et al. (2012) in the context of person-centered therapy, but directed to education, endorsed, for example, the feasibility of making both feelings and scientific and mathematical knowledge explicit under an artistic bias in Graduate Studies. The artistic languages—such as painting, music, poetry and others—that materialized the projects of the 'Expo(r)-(po)sição Art(sci)culada' allowed students to express, in a sensitive and creative way, complex understandings about scientific-mathematical phenomena (e.g., involving historical-epistemological and conceptual discussions), generating deep and authentic meanings. This approach mobilized subjectivity and corporeality, recognizing knowledge as a construction that is not only cognitive, but also affective, symbolic and experiential, thus promoting more integral and humanizing formative processes.

This expressive experience was directly articulated with the proposal of the course, conceived as a dialogical, welcoming, and co-creative space, in which professors acted as facilitators and graduate students assumed the leading role in their learning (C. Rogers, 1978). This setting expresses, in a concrete way, the concept of 'learning to learn', understood by C. Rogers as a continuous and significant process, in which the subject mobilizes internal and external resources to build knowledge based on their

own experiences, interests, and needs. From this perspective, learning goes beyond the mere 'acquisition of contents,' focusing on the development of autonomy, creativity, self-confidence, and the ability to make conscious choices, solve problems, and critically adapt to new contexts. By favoring this type of experience, the course contributed to the (re)humanization of the educational process by recognizing the student as an integral being—who feels, thinks, imagines, interprets, and transforms themself and the world around them through their unique ways of learning.

It is the different ways of being, knowing, understanding, and conceiving—that is, pluridiversification, and not uniformization—that Feyerabend (1977) recognized as fundamental for the construction of knowledge. The students' free choices regarding the scientific-mathematical themes and artistic languages used in the authorial projects evidenced the mobilization of methodological pluralism by enabling multiple ways of representing, interpreting, and communicating knowledge, in line with Feyerabend's criticism of epistemological rigidity.

Finally, the theorization emerging from the data qualifies and gives credibility to the feasibility of providing freedom to learn in Brazilian Graduate Studies by providing, in the context of an elective course—based on the interlocution between C. Rogers, N. Rogers, and Feyerabend—the artistic expressiveness of scientific-mathematical knowledge through projects designed (not only) for Basic Education—reverberating, beyond the university and academy, more human and plural perceptions to teach and (re)learn (about) science and mathematics.

Final (Ex)positions

"In art, the technique / the concept / […] mathematics / […] statistics / […] the rule / […] the process / the object / […] // in science magic / mystery / […] poetry / […] metaphor / […] chaos / […] grace / the subject / […] // in art art / in science science", writes lyricist Rennó (1996) in his poem 'Art and science'. A writing that harbors a way of (de)characterizing what comes to be presented: a 'lifeless' science and an art that vibrates. However, if the intention is to shuffle the areas to entangle them, why not 'in art the science' and 'in science the art'? This question echoes and is answered in the 'Expo(r)-(po)sição Art(sci)culada', in which graduate students exercise tying—the creative and expressive fusion between science/mathematics and art—by presenting authorial projects that integrate scientific-mathematical themes with artistic languages. The exhibition, originated in the elective course 'Interfaces' of the PPG-ECFP, in continuing education of teachers, is a space for sensitive and conceptual experimentation, in which rational and imaginative thinking intertwine, mobilizing a plural and humanized epistemology.

The artistic-scientific/mathematical projects developed in this course and presented at the 'Expo(r)-(po)sição Art(sci)culada' can be reused by the students themselves from different perspectives. For those who carry out teaching activities, they can be incorporated as resources or teaching materials in their classes. Students of the course 'Interfaces' who occupy coordination positions also recognize the applicability of

the projects. "In my role as coordinator, I can present the experiences of colleagues [the other projects produced in the course], as well as my own. In this way, we can provide subsidies for teachers to rethink their classes in a more creative way", says D7. In the case of master's and doctoral students, the projects can be integrated into the teaching units linked to ongoing research. In addition, other basic education teachers can use these projects and adapt them to different contexts and contents, contributing to the construction of didactic materials that integrate arts, sciences and/or mathematics. Thus, the elective course 'Interfaces', offered in the Graduate Program, shows the potential to expand to other educational contexts. As D3 points out, it "[…] can be offered not only in the academic master's degree, but in the professional master's degree, […] because we all leave with products". With the necessary adaptations and contextualization, it can also be converted into a workshop or even be reduced and integrated into courses in undergraduate courses, as proposed by Jorge and Peduzzi (2022c).

These educational implications corroborate the theorization built in this investigation by evidencing the feasibility of promoting formative experiences based on the freedom (total or partial) to learn about being and knowledge, in different formal and non-formal spaces, through historical-epistemological, conceptual, scientific, mathematical, and artistic articulations. Based on Rogerian and Feyerabendian discussions, such experiences favor different ways of thinking, creating, expressing, socializing, analyzing, and communicating knowledge—especially scientific-mathematical, through artistic language—in a more humane environment that is welcoming to plurality.

In order to effectively ensure this freedom of the student, it is necessary for the teacher to exercise trust, recognizing that the educational process presupposes delivery, listening, risk, and co-authorship. For those interested in the proposal, but who do not feel fully comfortable with full autonomy, an alternative is to replace the four weeks without meetings with face-to-face classes, intended for monitoring and implementing the projects, thus minimizing the risk of non-completion.

Among the beneficial actions that emerge from this investigation is (i) the proficiency of the transdisciplinary experience by the students when they get involved in its discussions and activities, and (ii) the construction of more plural actions involving contents, methodologies, social, cultural, affective exchanges, among others, which (re) humanize the teaching and learning process of individuals and of scientific-mathematical knowledge. Another contribution, indirect to society, academy, etc., involves the contact of the local/regional community with academic production from a more human perspective, from the execution of the 'Expo(r)-(po)sição Art(sci)culada,' open to the public—seeking to break with compartmentalized and hierarchical academic barriers.

Authors' Contribution

Conceptualization: Jorge, L.; **Data curation:** Jorge, L.; **Formal analysis:** Jorge, L.; **Funding acquisition:** Santos, B. F., Santos, B. F.; **Investigation:** Jorge, L.; **Methodology:** Jorge, L.; **Project administration:** Jorge, L., Santos, B. F.; **Resources:** Jorge, L., Santos, B. F.; **Supervision:** Jorge, L., Santos, B. F.; **Validation:** Jorge, L., Santos, B. F.; **Visualization:** Jorge, L.; **Writing – original draft:**Jorge, L.; **Writing – review & editing:** Santos, B. F.

Data Availability Statement

All dataset were analyzed in the current study.

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