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PERSPECTIVE

ARTICLE-OPINION: SCIENTIFIC BIOGRAPHY AS POSSIBILITY TO VALUE A MORE FEMININE AND BLACK CHEMICAL SCIENCE

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ABSTRACT:

In this paper, I present the evaluation process of the article "Scientific biography as possibility to value a more feminine and black Chemical Science" through an analysis of its axiological, methodological, factual, and historiographical domains. In axiological terms, I present the evidence and the train of thought that led me to understand that the paper, despite being intended as an exploratory research, demonstrated a previous hypothesis, that the biography of a black female scientist could promote discussions about race and gender in teacher training. In the methodological domain, I explore the inconsistencies that this previous hypothesis had for the development of the methodology. In the factual domain, I discuss the importance of presenting data classified by gender, race, and geographic location. When it comes to history and historiography, I present the discussions with the authors regarding the construction of teaching material that was not presented to me in the first version. I close the work by indicating that the final version has become more coherent and its hypothesis has been attenuated. The work presents above average quality and methodological rigor, in my opinion, and the process was extremely interesting, generating pertinent questions to our area of research as a whole.

Keywords:
Methodology;
Values;
Evidence;
Historiography.

ARTIGO-PARECER: BIOGRAFIA CIENTÍFICA COMO POSSIBILIDADE PARA A VALORIZAÇÃO DE UMA CIÊNCIA QUÍMICA MAIS FEMININA E NEGRA

RESUMO

Apresento o processo de avaliação do artigo "Biografia científica como possibilidade para a valorização de uma ciência química mais feminina e negra" por meio de uma análise de seus domínios axiológico, metodológico, factual e historiográfico. Em termos axiológicos, apresento as evidências e minha linha de raciocínio que me levaram a compreender que o trabalho, apesar de se designar uma pesquisa exploratória, demonstrava ter uma expectativa anterior, a de que a biografia de uma cientista negra poderia promover discussões acerca de raça e gênero na formação de professores. No domínio metodológico, exploro as incoerências que essa hipótese anterior teve para o desenvolvimento da metodologia. No domínio factual, discuto a importância da apresentação de dados em classificação de gênero, raça e localização geográfica. Em se tratando de história e historiografia, apresento as discussões com os autores relativas à

Palavras-chave:
Metodologia;
Valores;
Evidências;
Historiografia.

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construção de um material didático que não me fora apresentado na primeira versão. Encerro o trabalho indicando que a versão final tornou-se mais coerente e sua hipótese, atenuada. O trabalho apresenta qualidade e rigor metodológico acima da média, na minha opinião, e o processo foi extremamente salutar, gerando questões pertinentes para a nossa área como um todo.

INFORME DE ARBITRAJE: LA BIOGRAFÍA CIENTÍFICA COMO POSIBILIDAD DE VALORAR UNA CIENCIA QUÍMICA MÁS FEMENINA Y NEGRA

RESUMEN:

Presento el proceso de evaluación del artículo "La biografía científica como posibilidad de valorar una ciencia química más femenina y negra" a través de un análisis de sus dominios axiológico, metodológico, fáctico e historiográfico. En términos axiológicos, presento las evidencias y mi línea de razonamiento que me llevaron a comprender que el trabajo, a pesar de pretender ser una investigación exploratoria, demostró una expectativa previa, que la biografía de un científico negro podría promover discusiones sobre raza y género en los futuros docentes. En el ámbito metodológico, exploro las inconsistencias que tuvo esta hipótesis previa para el desarrollo de la metodología. En el ámbito fáctico, analizo la importancia de presentar datos en la clasificación de género, raza y ubicación geográfica. En cuanto a historia e historiografía, presento las discusiones con los autores respecto a la construcción de material didáctico que no me fue presentado en la primera versión. Cierro el trabajo indicando que la versión final se ha vuelto más coherente y su hipótesis se ha atenuado. El trabajo presenta, en mi opinión, una calidad y un rigor metodológico superiores a la media y el proceso fue sumamente saludable, generando preguntas pertinentes para nuestra área en su conjunto.

Palabras clave:
Metodología;
Valores;
Prueba;
Historiografía.

STARTING A CONVERSATION, OR INTRODUCTION

Anyone who works with history and philosophy of science understands that a good analysis of a scientific episode involves detailing the evidence on which a theory or hypothesis is based, the methods devised to collect such evidence, and the values, expectations and objectives of the scientists involved, including those of contextual nature that may have had epistemic effects in the episode. There are three domains of science, therefore: factual, methodological, and axiological. Over time, I came to understand that these domains are part of any area that seeks to produce knowledge, including science education research. Moreover, I feel that the ability to evaluate these three dimensions allows criticism capable of generating a more robust knowledge.

I agree with Laudan (1984) when he states that a theory of rationality demands understanding the sophisticated relationships that exist between values, methodologies, and scientific facts. In this sense, there is a logical reason for science, including a more socially applied one such as science education, to be done in a community. It is not possible to expect researchers to identify all the limitations of their investigations by themselves. Rigorous criticism is the way for the three domains of knowledge production to adjust in the best possible way, producing the best possible knowledge.

I would thus like to state what I understand as the importance of peer review. For me, the referee's work has two layers, one didactic and the other, epistemological. Didactic because, despite being fellow

researchers, we are also permanent learners. There are aspects of the structure of an academic work that can be more transparent to those who did not take part of the investigation. Often, as researchers, we have the impression that our work has no small contradictions and that our theoretical or contextual expectations have not largely influenced our communications. Reviewers play a didactic role by questioning points that often escape us and, along the way, this questioning can make us better understand the theoretical and methodological gaps, and the axiological expressions that can bring forth future criticism. As it is an internal and anonymous evaluation, this is a didactic instance, as it allows certain points to be duly reviewed and corrected in advance, and future research to be more restricted to the limits indicated by the referees.

For the same reasons, I also understand that this is an epistemological instance, because it allows knowledge itself to go through a round of methodological, factual, and axiological criticism before being published, thus biding time to review data and points that weaken the hypotheses put forward. To this, I add another distinction: I am in agreement with Longino (1990) when she states that peer review is the first instance in which one can observe whether a researcher's implicit values appear, even tacitly, in their manuscript.

The human and contextual aspects that we insist exist in the exact sciences also exist in a more social-applied science, such as science education. What I mean by this is that our expectations also permeate our research, even if we try our best to deflect them. However, this does not mean to say that we incur bad science, bad academic knowledge because of it. It simply means recognizing that publication should not be the final objective of an academic work, but rather its circulation, and understanding criticism as an essential part of the process, something that has the potential to improve our research, as well as yield new ones.

Therefore, I dedicated myself to diligently criticizing the article "Scientific biography as a possibility for valuing a more feminine and black Chemical Science", not because I found it to be of poor quality, but precisely the opposite. Good investigations deserve even more zeal, even more care. Good investigations have potential for reach, fertility, precision. Understanding that this is a manuscript about an investigation that excelled in methodological rigor and addressed a topic of increasing relevance, I pointed out a series of questions of methodological, factual, and axiological nature that were evident in the manuscript, although they are very typical of the research in science education, especially in the cases of field investigations and exploratory surveys.

I decided to divide this article-opinion into five sections and, of course, final considerations. Three of them are from the domains that make up science – axiological, methodological, and factual. One of them is dedicated to historiographical issues. These first four are directly related to the first version of the manuscript, received in May 2023, wherefore I include some of the authors' replies and, when relevant, my rejoinders. The fifth section concerns my interpretation of the final version, what was changed and what was maintained, according to my my first evaluation.

AXIOLOGICAL DOMAIN

Oftentimes, our implicit expectations show through in our work, despite our best efforts. My reading of the manuscript led me to understand that the work was an investigation whose hypothesis was that biographies of black female scientists can broaden the discussion about issues of race and gender in teacher training. I drew this conclusion by the title and a series of excerpts. Almost the entire introduction was focused on the defense that biographies can provide identification between readers and scientists, especially if the latter are not European men, figures generally praised in textbooks, even if only in passing. It is a fact that the subsequent section, which explored the literature on biographies in science education, featured authors who do not necessarily focus on aspects of science regarding gender and race. Yet, with the authors' own argument, that very section concluded that biographies have the potential to challenge stereotypes and provide a process of identification on the part of female students, and problematization of the masculine pattern, for male students.

There were also other excerpts that created the impression of a dominant hypothesis during the exploration of the results and the introduction of the methodological design. The data collection instrument consisted of eleven question, eight of which seeking to understand the associations between gender, race and science made by the students. However, the most powerful impression arose from the interpretation of the results of two of the questions that are not directly associated with such subjects, namely, questions 10 ("what characteristics of science and scientific knowledge are present [in the biographical text]?") and 11 ("Describe everything that can interfere with the production of scientific knowledge [in the biographical text]") (Gomes & Francisco Jr., 2024, p. 19). I say this because, when analyzing the results, the authors emphasized that students were more inclined to describe characteristics generally understood as internal to science, such as its methods and problem design, in addition to paying more attention to institutional issues. These results, in themselves, would not indicate the search for the validation of a hypothesis, but rather an effective exploration, as stated by the authors in their reply. Nonetheless, in the final considerations, there was still a tendency to understand this result as deviant, indicating that "although many have identified characteristics of scientific work [...] that were sought to be highlighted in the biography, the participants focused to a greater extent on internal aspects, such as scientific problem and methods" (Authors, first version).

My reading path led me to interpret that the manuscript had a hypothesis, whose only partial validation was understood as a deviant result, demanding didactic interactions in the classroom for a better emergence of topics of gender and race. Consequently, I indicated that the investigation seemed to me to have a tautological nature, that it was designed to prove a hypothesis. The authors responded, expressing understanding of the basis of my criticism; therefore, they changed the terms of the research question (from "potentiality" to "possibility") and reorganized excerpts that could give such an impression. Furthermore, they indicated that they had not found the word "hypothesis" in the sense that I understood it in the paper and that they recognized that exploratory research should not be guided by hypotheses.

I would like to indicate, once again, that a hypothesis does not need to be stated in order for it to be identified by readers. As values and expectations are closely related to methodologies and facts, when I presented a criticism regarding the methodological structure, I received, among equally methodological arguments, one of axiological nature. This criticism and these arguments will be better appreciated in the next section; however, I want to work here a little more on the axiological position presented in the authors' reply.

> We would also like to emphasize that our interest is not exclusively in the "capacities related to the analysis of science in terms of gender and race", but rather in general epistemological aspects, as emphasized, since the original version, in the objectives and later resumed in the final considerations (Authors, reply).

In fact, after the changes that mitigated the impression of a hypothesis – the change in the word potentiality in the research question and several other excerpts – it is possible to better understand the intention of the authors. It is important to emphasize, however, that the title continues to show an inclination towards the topic, as well as the effort spent in defending the importance of a historical approach able to break stereotypes and promote identification among students. It is worth noting that, throughout the text, there is little theoretical depth in general epistemological aspects, reinforcing the impression that there is a more important objective for the authors.

The very differentiation between the internal and external dimensions of science, classification chosen for the answers to question 10, was also indicative of a vision that separates the logical-methodological scope from the contextual, and, therefore, the general epistemological aspects from those of gender and race. Although this classification emerges from the students' responses to the questionnaire, in an attempt to demonstrate where their perceptions of aspects of science lie, it was ultimately a classification chosen by the authors. It is important to emphasize that the dichotomy between what is cognitive and what is contextual is a theme that has mostly been overcome in the philosophy of science (with some important exceptions), due to the pro-

tagonism of the history of science as a body of evidence for the philosophy of science. In any case, what I want to reiterate is that this separation and the consequent understanding that more intense efforts must be made so that students grasp more contextual aspects, for me, are also a demonstration that there was something in the biography, the implementation and the authors' own expectation, even if not stated. However, it is worth noting that this point of criticism was considered by the authors: "The separation between internal and external was suppressed, as it would lead to other discussions, which could in fact be shadowed" (Authors, reply).

Finally, it is important underline another point that led to my impressions: the structure of an academic text. To the reader, textual structures should be indicative of a researcher's intentions. Our field habitually introduces theoretical references and, with them, the justification of a paper, before presenting the investigation, whatever its type. In fact, many pages are usually spent on introducing the ideas of authors who are often already widely known; this is not the case of the manuscript in question, however. Its section of theoretical references on scientific biographies in education is very succinct and well-dialogued, which is very good for the reader. But I would like to emphasize that such a structure – introduction, theoretical references, methodology, results, final considerations – brings about the perception that there is an initial hypothesis. I wonder whether, in the case of exploratory research like this, it would not be more coherent to change the structure of the text, with the theoretical references after the results, in order to better align the readers' perception of the researchers' exploratory methodologies and expectations. In any case, it is important to clarify that this is not a criticism I presented to the authors, because it was an idea elaborated with the production of this article-opinion. Even so, I understand that it is an interesting reflection for the area as a whole.

METHODOLOGICAL DOMAIN

Undeniably, the paper presents methodological rigor that is above the average among research with people in our field. Atypical but welcome precautions were taken. The effort to expand the universe of participants is worthwhile, not just in number, but geographically – the authors collected and examined responses from students from three Brazilian regions, even though the majority were located in the Northeast region. The initiative to evaluate the biography and validate the questionnaire by two Chemistry Education researchers, PhDs in the history and philosophy of science, was also very positive. These actions reveal a concern with the validity and reliability of the data and, I repeat, are not the traditional practice in exploratory qualitative investigations in our area, although they should be.

An expression I used in evaluating the work – methodological design – caused discomfort to the authors, who understand it as originated from experimental research; they emphasized they prefer the term "methodological procedure". Despite conceding that this may be the origin of the expression, even if I have not found sources for it, I would like to use this space to reflect upon the difference between method and methodology, with which I hope to draw conclusions directly related to my central argument: that our expectations permeate the way we investigate.

While methods concern essential techniques and procedures to achieve a partial or general objective, methodology concerns the study, the knowledge of the methods with which this objective will be carried out. In this sense and in general, we can understand that methodology is the intentional understanding of which methods best suit the investigation we want to develop. Naturally, and frequently in our field, we summarize methodology as the categorization of the research we intend to carry out. We often refer to methodology as qualitative or quantitative, in relation to the types of evidence we are going to collect; as experimental or exploratory, according to the intention of testing or recognizing the object of study; such as field or bibliographic, depending on the object, to name just a few examples. Although this description is correct, it is also incomplete, for methodology is also concerned with the intentional study of what are the best methods for our re-

search to achieve its objective, whatever the combinations of types of evidence, objects investigated and other essential research entities. What happens is that these methodological choices are directly dependent on the particularities of the investigation and usually unannounced. Even so, they require explicit justifications, or it will be up to the reader to try to understand why certain methods, procedures and approaches were chosen.

Thus, what I want to defend is that methodologies are not autonomous entities, independent of our expectations, values and objectives, nor are they detached from the demands of the data we want to collect. Furthermore, if some of their aspects can be readily classified, others make themselves evident through the methodological decisions made. What I mean by this, anyway, is that there is never a lack of intention in research. If we choose to proceed methodologically in one way, it is because there are restrictions on our objectives and the facts we intend to understand. Hence, a methodology is designed as much as it is carried out; perhaps the biggest difference lies between a pre-research design, more typical of experimental investigations, and a procedural design, more typical of explorations. It is worth as a point of curiosity here: we, researchers in the history and philosophy of science in teaching, broadly advocate teaching that, in exact sciences, there is no defined method, that there is a sophisticated dynamic between theory, experiment and observation. The same goes for research in science teaching, as expected.

As expectations are directly associated with methodologies – that is, as we often design our investigation based on our expectations – and as I identified a hypothesis (even if not stated) that biography had the potential to promote epistemological discussions of gender and race, I indicated in the assessment that it would be very important to have a control group. Control groups are essential tools for considering whether the expected potential can be associated with the phenomenon under study. I even suggested two possible approaches for such a group: one in which a philosophical text with the same objective would be applied, or one in which a work of science fiction with the same theme would be exposed, such as Octavia Butler's books.

The authors replied, emphasizing that they anounced that the research is qualitative and exploratory in nature, a type of investigation in which a control group does not make sense.

> [...] the research is designed as exploratory with an interpretative nature. Exploratory in the sense of seeking initial evidence of meanings produced about the epistemology of science. The study does not seek to "identify potential", as the assessment claims, but rather possibilities. These are words that denote different meanings for research, as potential is based on a value judgment, which we try to avoid (Authors, reply).

I agree with them; in fact, control groups are about testing hypotheses, not recognizing a reality, which is the goal of an exploration. However, as I did in the previous section, I need to reiterate that many aspects of the text suggested and still suggest an implicit hypothesis. In this sense, my indication in the assessment could have been to change the type of research announced - which would, in turn, also generate an inconsistency between expectations and methodologies, because the past methodological execution was that of an exploration, without a control group.

It is also worth reflecting on the choice of the research universe, for which three justifications were given: (a) geographic variety to increase reliability; (b) teachers in training, due to the "need to expand the discussion and encouragement of women in science" (Gomes & Francisco Jr., 2024, p. 6), and (c) students who "had not taken subjects that included history and philosophy of science" (ibid). I will address justification (a) in the following section on the factual domain, because this methodological choice has implications for evidence collection. I will focus here on justifications (b) and (c).

As for the choice of undergraduate students, I think it is an appropriate approach. Research in science education has sought to show the educational potential of the history and philosophy of science, for a variety of reasons (Matthews, 1995; Lederman, 2007; Matthews, 2012). Of course, research has also shown the challenges which it involves. There is great difficulty in associating history and science teaching due to rigid curricula, tacitly widespread teaching practices and the lack of access to appropriate historical sources for different levels

of education (Martins, 2007; Damásio & Peduzzi, 2017). Initial teacher training is, in fact, the most favorable environment to initiate a possible paradigm shift that reaches basic education classrooms. Furthermore, it is essential to take into account that the history and philosophy of science themselves are important learning topics, no matter the school level, as we live in a world based heavily on science and technology (McComas et al, 1998). However, none of this information was included in the text; the justification for this approach, again, was general in epistemological terms and assertive in relation to encouraging women to study and be interested in science.

I was also curious about the selection of subjects who had not been exposed to courses of historical--epistemological nature. Although I think the choice is valid, it once again leads me to the unstated hypothesis of the work. The presence of students who had had formal contact with the topic would possibly lead to group discussions that would change the results, which would not necessarily be a bad outcome. Furthermore, the biography apparently addresses issues that historical-epistemological courses touch upon only in passing. Thus, it seems to me that this choice may also have something to do with the implicit hypothesis: being formally exposed to a material like this for the first time, what conclusions would these students draw on the issues of race and gender (present in eight of the eleven questions)?

It is important to clarify, however, that the reflections brought up in the latter two paragraphs were not part of the assessment. I only left a comment box in the text, about justification (c), which was also delivered to the authors. However, I find space here to expand this discussion with members of the area as a whole. What I bring here is anecdotal evidence, but throughout my academic career, I witnessed colleagues stating that cohorts are cohorts, they require no further justification. I have my doubts about this, especially when it comes to field research or general research with people. The justification for a choice of universe can reveal many things about the researcher's expectations and, on the other hand, influence the selection of what the investigator understands as evidence.

FACTUAL DOMAIN

As our expectations shape our methodologies, they can also play an important role in our choice of evidence, whether propagated by the chosen methodology or not. I indicated in the previous section that one of the justifications for the cohort – the geographic expansion to increase reliability – would be better explored based on the perception of the factual domain. Once again, I reiterate that I think the choice to expand the geographic scope of the cohort is valid and, once again, I indicate that I felt a lack of justification for such a choice. But what is most interesting is the relationship that this choice ended up having with the evidence presented: none. The responses were not classified by institution, which would allow the reader to associate geographic location with the responses. The authors responded that there was no significant variation. Readers are left to abide by it, even if this evidence could have been presented in the form of a simple table in the discussion of the results for each answer.

The same occurred when I asked whether there were differences by gender or race. The racial profile of the students, in fact, is not an identification item in the questionnaire, although the research is about the possibilities of a scientific biography "to value a more feminine and black chemical science" (Title). But this is a methodological point and here I want to reiterate the factual part of this issue. Once again, the reader is left to believe that there were no significant differences. The question is: when one of the theoretical justifications is that the contact with black women's stories can provide an identity process among other girls/women and a problematization of the masculine pattern among boys/men, the work should offer it as an explicit result.

In research with people, knowing the demographics that sources the data is essential, although little explored in our area. On the one hand, the subgroup chosen for a survey may not be representative of the average student, as Kanim and Cid (2020) observed in the American context, leading to conclusions that cannot always be extended to everyday school practice. On the other hand, I note that it is impressively frequent that students'

responses are presented without proper profiling in surveys involving people in Brazil. This led me to comment on an inconsistency in our area, which generated another discomfort among the authors. It is practically consensual that our students are not conceptual blank slates, that they bring their knowledge to the classroom and that this knowledge influences the way they learn and see the world, as shown by research into spontaneous conceptions in the 1980s (Driver, 1989), by the importance of subsumers in the Theory of Meaningful Learning (Ausubel, 1968), and by the critical pedagogy of Paulo Freire (1987; 1996), to name just a few examples. However, because we do not give factual value to who our students are demographically, I tend to understand that the field implicitly sees them as ideological blank slates (tacitly contradicting Paulo Freire's body of work).

The authors' discomfort came from the fact that there is actually a subsection entitled "Students' prior knowledge about scientists", which they understood to have offered the reader a deeper understanding of the students. There, the authors dedicate themselves to analyzing students' answers to questions 1 to 6 in the questionnaire. From there, some results were obtained that reiterate the idea that there is little contact among students with uncelebrated characters in science, since the majority of students indicated that they had only had contact with other stories during their undergraduate studies and that they have great difficulties in thinking readily of examples of female scientists.

However, analyzing the students' profiles could have taken the results further. There are excerpts from answers offered by the authors that lead us to think that some of them had previous knowledge on the subject, even political positioning, such as the answers from students E06 and E08 in table 4, E45 and E06 in table 6 and E49 and E19 in table 8. In this last table, E49 seems to use inclusive language. I know that a more survey-oriented investigation does not have the ability to triangulate this data with interviews and observations. Still, these results cannot be directly correlated with the biography itself, as they may have roots in other areas of students' lives, such as interactions on social networks, for example. Of course, this type of understanding would only come from interviews and observations, which are not applicable to surveys. But one thing in a survey is possible: the categorization of quantitative results by gender, race and geographic location of students, which is a central part of the investigation.

Granted, the authors indicated there were no significant differences in responses, but simple data would help readers draw their own conclusions. The authors responded by saying that "even to mention two female scientists, only 13 out of 61 (42 women) were capable" (Authors, reply), which led me to believe that they did not understand my indication of a simple categorization of results, which could have been done in one sentence and would show the reader, quantitatively, that this distribution was, in fact, insignificant in terms of gender and race. Of these 13 who mentioned two women, how many were women, how many were black, how many were in each institution?

I want to consolidate my argument with the analysis of another point that I indicated in the assessment. In question 10, many students demonstrated that they recognized more cognitive and methodological elements of science than contextual ones in the text. As the impression I had from the analysis of these results, especially in the final considerations, was that this was an unexpected result for the authors, I assessed that this could be associated with other factors, not just a limitation of the biography. I indicated, for example, that the chemistry student is usually more inclined to methodological issues, due to the very nature of this science; therefore, I understood that this result could be correlated to other things and that a deeper demographic analysis could have revealed a variety of interpretive possibilities for this result.

The authors asserted that "There is a currently very large homogeneity in the curricular structures of undergraduate courses, as well as in the socioeconomic profile [...] which would explain this, although such a discussion is not the intention of the research" (Authors, reply). However, homogeneity in large databases like INEP[1] has to do with small average variations; this homogeneity does not necessarily apply to the cohort, precisely because the institutions were not intentionally chosen by the authors in order to replicate the usual

profile of chemistry undergraduates. It therefore seems to me that this counter-argument by the authors is inconsistent with the initial purpose of geographically expanding the universe of students, an unnecessary action if it is taken as an axiom that any subgroup studied is a replication of the broader national profile.

It is true that it is impossible for one research alone to consider every idiosyncrasy of each participating subject. On the other hand, there are experiences shared by geographic location, gender and race that can be associated with the results of any research. These experiences, in fact, do not fail to inform the student's way of seeing the world as soon as he enters the classroom. This is why I used the provocative expression "ideological blank slate": because in investigations, especially like this one that had race and gender as one of the axiological points and geographic location as a methodological one, this type of data must be offered to the researcher in a more detailed manner, even if the researchers consider it as insignificant. But I would like to clarify that this is not a criticism just to the paper under analysis, but to the entire field. And finally, as a curiosity, I also see this point as an inconsistency in research in the history, philosophy and science teaching itself: we want students to understand that scientists have ideological profiles and that this often influences the way they practice science, but we have difficulty in associating the same effect with students who are our research subjects, of recognizing that who they are influences the evidence they provide us.

Regarding another practice in the area, and not a specific problem of the manuscript in question, I raised the issue of offering evidence in the form of excerpts curated by researchers. In total, the researchers had access to a universe of approximately 400 answers to open questions, but presented only a few examples in the manuscript. Logically, it would be impossible to present all the answers and I consider it positive that categories with quantitative data were created for the reader's better appreciation. However, the excerpts offered as examples do not often resonate with the reader; some seem too generic or too associated with the biography, to which I did not have access during the evaluation (which will be discussed in the next section). Considering the possibility that such excerpts were chosen because they were the best, and because there was no triangulation with other data collection methods – which a field investigation would provide – it is worth asking what effects the researchers expected when presenting this evidence. This was an issue highlighted in the assessment that was not replicated by the authors. At this point, I consider Ensaio's initiative to deposit empirical research data in the dataverse to be fundamental. Although I did not have access to this data during the evaluation, in compliance with the anonymous evaluation rules, I will certainly return to them as soon as it is published. I feel it is important to emphasize again that, in any academic area, good papers should not have the mere publication as their final objective, but its subsequent circulation and consequent criticism. The essential scholarly work of critique and replication will certainly gain traction with access to such data.

HISTORICAL AND HISTORIOGRAPHICAL DOMAIN

In the first version of the manuscript, the authors stated that the research was carried out in three stages, the first of which was the development of Alice Ball's biography, based on primary and secondary sources. However, my understanding was that the manuscript reported only one piece of research – the survey – and did not address the bibliographical research and instructional development that led to the biography as a result. I don't think this is a problem; after all, there are enough topics for exploration in the research presented. I hope, on the other hand, that the equally investigative process of transforming historical information into teaching material will be published and widely appreciated. It is important to stress again that readers of the manuscript and this article-opinion have access to the biography, the final product, at Ensaio's dataverse.

It turns out that a consequence of this choice was the fact that I did not have access to the biography for analysis when I received the manuscript, and this resulted in my inability to evaluate the evidence offered by the authors beyond what they themselves indicated in the analysis of the results. It was my responsibility, therefore, to briefly evaluate the justifications for the didactic use of a scientific biography.

The work dedicates a section to a dialogue with the literature on scientific biographies and their didactic possibilities. It presents sources that argue that these works can be a means of introducing lesser-known characters in science and, in addition to providing perspectives on the science produced, they can also humanize scientists, adding contexts and particularities to their academic lives. There are many positive possibilities, but, in the first version, no source or position more critical of these materials.

This critical stance is essential and was indicated by me as fundamental for the publication of the paper. As there was no section dedicated to the investigative work of developing the biography, it was not possible to know what the authors characterize as a good scientific biography. Admittedly, they indicated that they used both primary and secondary historical sources; however, there remains the question regarding the reliability of these sources. History of science has also undergone major changes in recent decades and research that was previously considered good has started to be challenged. It is not uncommon to find papers that present new perspectives for episodes whose stories we thought were well known. To cite some examples, there are questions about the "controversy" between Newton and Huygens' optics (Moura, 2016), the importance of the Michelson-Morley experiment for the Special Theory of Relativity (Kragh, 1987) and the indication of Max Planck as a proponent of energy quantization (Kragh, 2000).

A scientific biography is a historiographical work and consequently demands caution of the same nature (Kragh, 1987). Even autobiographical primary sources need to be carefully approached. Scientists, and whoever tells their stories, change their perspective during their lives. New sources emerge, historians with better scientific knowledge or knowledge of the researcher's native language find new evidence, among other possibilities. There is no classical objectivity in history of science: new discoveries of historical sources change our perception of past facts.

One of the sources presented in the section indicates that one of the objectives of a scientific biography is to praise the person being biographed. In my understanding, this objective has two sides that I want to evaluate. It is logical, on the one hand, that a biography can praise someone; after all, biographies of figures considered positive are often developed. Of course, biographies can also be made of hideous figures in history. In any case, biographies highlight some characteristic that, in that character, differs from the average human being. On the other hand, the choice of a biography, being itself a choice to tell the story of someone who made a great contribution, is made by the biographer, someone already enchanted (positively or negatively) with the character. It is possible – and often happens – that the author's esteem for the object of the biography influences the way the story is told. Therefore, historiographical caution and the author's axiological vigilance are fundamental – that is, their ability to review their own text and identify how much of their idealization of the scientist shows through the biography, how much there is of the subject and how much of the biographer himself are rendered by the biography. Certainly, the authors made a special effort, by validating the biography with the help of two researchers; there remains the question of how much of Alice Ball's story the evaluators knew through reliable sources. After all, those educated in the history of science are not obliged to know the entire history of science.

We cannot forget that the scientific biography produced had another purpose: it was developed to be a learning material. Here, I would like to raise questions for the area, because I myself would like to know if a direction is possible. Just because they have a protagonist, would biographies not give the impression of a heroic scientist? What weight should be given to the scientific community in such a text? How much history of the scientific community can coexist in the material before it ceases being a biography? Would the heroic and individualistic idea of science be a reasonable price to pay for a moment of appreciation of other characteristics of an important, but unknown, scientist? If so, what further actions can be taken to mitigate the individualistic idea of science?

THE FINAL VERSION OF THE WORK

Some important changes were introduced in the paper, certainly placating many of my impressions about the research work discussed so far. In the introduction, it is possible to notice that the authors included some more considerations on issues traditionally considered as epistemological and changed, as they had stated in the reply, the term "potentiality" for "possibility" in the research question.

In the section "Scientific biographies for historical, epistemological and social debate", the authors included a discussion about the limits of a scientific biography, as I indicated in the assessment and as I discussed in the section above. The insertion is really very good and brings precisely a discussion about the essential caution for the production of a scientific biography, pointing out that they can inadvertently convey an individualistic idea of science, but reiterating some fundamental precautions with an appropriate citation. It is also worth affirming that the final paragraph of this section, which is the authors' own argument, is dedicated to associating the construction of a biography with important aspects of the history and philosophy of science and, more importantly, it suppressed the excerpt which indicated that it was expected that biographies of black women could produce identification among girls and problematization among boys, which is more consistent with an exploratory research.

Before moving on to the analysis of the next section, I would like to clarify an essential point. My position is not against the capacity of scientific biographies of black women to produce such meanings among students; in fact, I believe this is a possible result, but it needs to be further investigated to show possible associations or causalities. Furthermore, the end of the section gave the impression of a previous hypothesis, which was definitely appeased with the new wording, in addition to demonstrating more methodological coherence with the exploration study itself.

In the "Methodological Procedures" section, the justification for an exploratory study was expanded. Even more important was the addition of robust justifications for the choice of Alice Ball as a protagonist, with sociological, epistemological, gender and racial reasons. Furthermore, a detailing of the biographical text was introduced, to which I did not have access during the evaluation, with the presentation of a table with the main sections of the biography and their summaries. What I was able to interpret from the syntheses involves her life, her methodological work, the theft of authorship and the posthumous recognition of her work. Those were highlighted by the authors in a subsequent paragraph, in which they argue that the text included varied characteristics of science, among which those we traditionally understand as more cognitive. Other methodological details were added, along with an exemplification of how the evidence coding process was carried out, in the description of data pre-analysis, and a more comprehensive description of the data exploration stage.

Interestingly, the authors chose to keep the results as offered in the first version, demonstrating that they did not understand the classification of responses by race, gender or geographic location as fundamental. Therefore, I feel obliged to underline the argument I presented in the section on the factual domain. It is true that many of the changes made up to this point attenuated my impression of a previous hypothesis and made the text more coherent with an exploratory research. However, the title of the paper and the presence of race and gender themes in eight of the eleven questions in the questionnaire continue to demonstrate a bias in the work, which, for me, is enough for the responses to also be analyzed from this perspective. Furthermore, I also insist that the methodological idea of expanding the universe geographically would be much better justified if it were also a category of analysis for each response, as I have already done in the section on the methodological domain.

I should point out that the sections dedicated to analyzing the results were also changed in order to mitigate the impression of a previous hypothesis. Excerpts were added, especially in the section "Senses about the epistemological understanding of knowledge production", to indicate that a series of factors were

expected with the answers to questions 10 and 11, including those of more cognitive, epistemic nature. The authors also removed the terms "internal dimension" and "external dimension", which certainly would generate philosophical conflicts. They also added to the discussion a reason for the students' inclination towards aspects of science related to their methodologies, emphasizing that this was a highlighted point in the biography. Added to the fact that the final considerations were also changed, emphasizing all aspects of science, I realize that the authors themselves understood that there was a bias in the initial version, corrected in the final version. I therefore feel that the authors' expectations are now more regulated, despite the title and the questionnaire still giving the impression that reigned on my first reading.

Finally, I would like to highlight that the authors added excerpts in which they indicate the limits of the investigation, pointing out that the text, in itself, was not enough to generate deeper analyzes of science as a whole and, above all, at the intersections between contextual and cognitive (which contextual values play a cognitive role in science). They also indicated the need for further non-exploratory research, which should account for classroom interactions. Finally, they also considered investigating the students' prior philosophical knowledge. For me, these additions are very meaningful. We cannot expect a research to be perfect, although many research reports in our field, especially in investigations with people, mostly indicate points of success. Scientific education deals with sophisticated objects and the limits of a research should be evident to researchers and, why not, to readers equally. It is within these limits that further research can focus, offering better results, stronger association relations, moving from the world of temporally and spatially isolated research, with a small universe, to that of robust research, capable of promoting stronger associations and possible generalizations.

MY FINAL THOUGHTS ON THE PROCESS

It is possible that the reader of this article-opinion will be led to the impression that I have seen too many gaps in the manuscript. My written expression tends to be assertive and my way of analysis, inherited from historical research focused on the relationships between science and values, is generally understood as such. Unfortunately, I feel that this was the authors' reaction upon receiving my assessment. I want to use this space to state that this is not true. The firmness of my criticism, present in the detail I tried to present here, is because I believe the work to be very good; I have already indicated my satisfaction with the rigor of the investigation and the changes made, which I reiterate. Unfortunately, because I am a physics professor, there is no space in my classes to explore the topic; if there were, I would certainly make use of the biography and try to take it to the classroom, even if I would not use the questionnaire developed in the research.

Many of the criticisms I made were more directed to the field of science education than to the authors, in fact. It is essential that our field seeks self-criticism more frequently, as reflecting on how our expectations relate to our methods and the evidence we collect is part of academic rationality. I want to confess, here, that I myself have produced papers that had inconsistencies like the ones I pointed out here, and I will probably continue to do so. I expect to experience criticism of this nature, no matter how uncomfortable I know I will feel. But academic knowledge needs to be rigorously criticized for it to improve, there is no other way. The process is uncomfortable, indeed, but inescapable.

Finally, I would like to share yet another interesting fact. Throughout the review process, I referred to the authors as "the female authors", as I was certain they were women. To my surprise, I discovered that one of the authors is male. I must emphasize that it was a pleasant surprise, in fact. Topics of race and gender in science are not only contextual, but they are often cognitive. We know of many episodes in the history of science in which supremacist views influenced expectations, methodologies and evidence – which is why I criticized the internal and external classifications of science. If they play a cognitive role, they need to be of interest to all who practice science, history of science, philosophy of science, and science teaching, because they are simultaneously essential to justice and epistemology.

REFERENCES

Ausubel, D. P. (1968). Educational Psychology: A cognitive view. Nova York: Holt, Rinehart & Winston.

Damásio, F.; & Peduzzi, L. O. Q. (2017). História e Filosofia da Ciência na Educação Científica: Para quê? Ensaio – Pesquisa em Educação em Ciências, v. 19, e2583.

Driver, R. (1989). Students' conceptions and the learning of science. International Journal of Science Education, v. 11, p. 481.

Freire, P. (1987). Pedagogia do oprimido, 17a ed. Rio de Janeiro: Paz e Terra.

Freire. P. (1996). Pedagogia da autonomia. 25a ed. Rio de Janeiro: Paz e Terra.

Kanim, S. & Cid, X. C. (2020). Demographics of physics education research. Physical Review Physics Education Research, v. 16, n. 2.

Kragh, H. (1987). An introduction to the historiography of science. **Cambridge University Press**.

Kragh, H. (2000). Max Planck: the reluctant revolutionary. **Physics World**.

Laudan, L. (1984) **Science and values**: the aims of science and their role in scientific debate. University of California Press.

Lederman, N. G. (2007). Nature of Science: Past, Present, and Future. In: Abell, S. K.; Appleton, K.; Hanuscin, D. (eds). **Handbook of Research on Science Education**. Routledge.

Longino, H. (1990). Science as social knowledge: values and objectivity in scientific inquiry. Princeton: Princeton University Press.

McComas, W. et al. (1998). The nature of science in science education: an introduction. Science & Education, v. 7, n. 6, p. 511.

Martins, A. F. P. (2007). História e Filosofia da Ciência no ensino: Há muitas pedras nesse caminho... Caderno Brasileiro de Ensino de Física, v. 24, n. 1, p. 112.

Matthews, M. (1995). História, filosofia e ensino de ciências: a tendência atual de reaproximação. Caderno Brasileiro de Ensino de Física, v. 12, n. 3, p. 164.

Matthews, M. R. (2012). Changing Focus: From Nature of Science to Features of Science. In: Khine, M. S. (ed). Advances in Nature of Science Research. Springer.

Moura, B. A. (2016). Newton versus Huygens: como (não) ocorreu a disputa entre suas teorias para a luz. **Caderno Brasileiro de Ensino de Física**, v. 33, n. 1, p. 111.

NOTES

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