RBECT Revista Brasileira de Ensino de Ciência e Tecnologia

Revista Brasileira de Ensino de Ciência e Tecnologia
ISSN: 1982-873X

https://periodicos.utfpr.edu.br/rbect

Conceptions about quantitative and qualitative research and the construction of science among undergraduate students at UERGS

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ABSTRACT

Epistemology, as a field of study of scientific development, is represented by different philosophers of science, each with their own system of explanation for scientific development. Despite the diversity of opinions emitted by these philosophers and the clash they often have with each other, the dialogue between them is possible and fruitful — as long as their own methodologies are used and that take into account the contexts and searches of each one. Thus, based on the contributions of different epistemologists, this paper seeks to identify the understanding of key aspects of science among students from five undergraduate courses at the State University of Rio Grande do Sul (UERGS). In methodological terms, the research can be considered qualitative, considering that data collection took place through semi-structured interviews. Once carried out, the interviews were analyzed through a process of discursive textual analysis, which classified the different positions of the students in three main themes: i) the way they understand science in their areas; ii) the role that quantitative research plays in their areas; and iii) the possibility of carrying out qualitative research in each field. Each of these themes was discussed based on epistemological references. As a result, it was possible to identify different understandings of scientific practice, both between courses and within each course. It was also noticed that statistics and quantitative data play a relevant role in most areas, even if their uses and functions are not always fully mastered by students. Finally, it was found that, although a considerable number of students considered it possible to carry out qualitative research within their areas, few were able to say how this type of research could be instrumentalized or if they would be easily accepted by their areas.

KEYWORDS: Epistemology. Philosophy of science. Student training. University education.

INTRODUCTION

When discussing the contributions of different theorists to the growth of science, Moreira and Massoni (2011, p. 9) state that the "Epistemology of Science is the study of the nature, scope and justification of scientific knowledge". In the sequence, they present, in general terms, important philosophers of science, such as Popper, Kuhn, Lakatos, Laudan, Bachelard, Feyerabend, Bunge, Mayr, among others. However, they do not take any of the explanations as the best for understanding science. By presenting them, the authors offer readers the possibility of recognizing themselves as major sympathizers of one or another view of science; so, if they wish, readers can delve deeper into reading only the authors with whom they have the greatest affinity.

Even if quick and objective access to the ideas of different epistemologists is something enriching and with the potential to direct students to references of greater interest, the deprivation of reading the authors' originals ends up hiding an important and common aspect between them: the very rhetorical structure with which epistemologists often construct their essays. It so happens that, as a rule, the argumentative structure of his works is largely based on criticism of his predecessors. This can lead those who study only one of these authors to believe that these ideas are largely incompatible with those of their rivals. As a consequence, concepts peculiar to each author, such as paradigms, research programs, research traditions and systems of statements can end up being treated as distant structures from each other to the point of making any type of dialogue unfeasible.

We can understand that each epistemologist's criticism of current explanations of science led them to construct distinct and internally functional explanatory models. As an example, we have the following models: Laudan's (2011), which focuses on problem solving; Kuhn's (1982), focused on the emergence of revolutionary research that breaks with a normal science model; Mayr's model (2005), on the distinction of Biology in relation to Physics and Chemistry; Popper's model (2013), which makes a clear definition of the boundary between science and pseudoscience through experiments and falsification of theories; and that of Lakatos (1978), which breaks the rigidity of paradigms without immediately attaching itself to the results of experiments considered crucial. However, these various complex systems that seek to explain an object share the same name, science — regardless of the line to be followed —, naturally leading to communication difficulties linked to the so-called incommensurability (FEYERABEND, 2011; KUHN, 1982; LAUDAN, 2011). This, in turn, would be related to the fact that "change theorists notoriously adopt a specialized and idiosyncratic terminology that makes it difficult to establish comparisons between what is being asserted and denied by rival theories" (LAUDAN *et al.,* 1993). This makes the comparison between different areas of science a first challenge to be overcome when working concomitantly with different areas.

However, the argumentative structure of these epistemologists should not be interpreted as a synonym of total independence between scientific conceptions, impossibility of dialogue between different areas, much less as an indicator that, individually, researchers (or even students) should be affiliated with just one of these explanatory lines (SILVA *et al.*, 2018). For, despite the scathing criticisms that philosophers of science level at one another, they equally declare mutual admiration and indebtedness. Examples of this is Kuhn: after admitting his admiration and interest in Popper's works, he stated that "almost every time we explicitly turn to the same problems, the conceptions of science, mine and Sir Karl's, are almost identical" (KUHN, 2011, p. 284). A second example would be Lakatos, who, before harshly criticizing Popper's demarcation criteria, states that "Popper's ideas constitute the most important philosophical development of the twentieth century [...]. My personal debt to him is immense: he changed my life more than anyone else" (LAKATOS, 1978, p. 180). Even more incisive is Feyerabend when explaining his motivations for writing "Against the Method", which, according to the author "is the first part of a book [...] that would be written by Lakatos and me. It fell to me to attack the rationalist position; Lakatos, in turn, would reformulate this position, to defend it and, in passing, reduce my arguments to nothing" (FEYERABEND, 1977, p. 7).

A careful reading of different epistemologists indicates how fruitful criticism and dialogue with differences can be, given that "truth is the child of discussion and not the child of sympathy" (BACHELARD, 1978, p. 81). Thus, investigating how students from different courses understand science in their areas is a promising proposal, in terms of understanding the potential for epistemological enrichment offered by the courses themselves. In this sense, the present work seeks to understand how undergraduates from five courses at the State University of Rio Grande do Sul (UERGS) understand certain aspects of science within their areas. The courses considered in this research were: Bachelor of Agronomy; Bachelor's Degree in Food Science and Technology; Bachelor's Degree in Bioprocess Engineering and Biotechnology; Bachelor in Environmental Management; and Degree in Pedagogy.

The students of these courses were interviewed about a series of aspects related to doing science, and in this work, above all, considerations related to four of the questions addressed are presented, namely: 1) how science is done in each course; 2) what might be considered typical research for the area; 3) what is the role of statistics and experimentation for the area; and 4) what is the possibility and receptivity of the use of methodologies more common to human sciences within the area.

DEFINING AND DEMARCING SCIENCES

When referring to basic references of scientific methodology disciplines (which includes basic bibliographies of the five undergraduate courses to be analyzed), it is common for them to bring their own systematization and methodologies as indicators of what may or may not be considered scientific (CERVO; BERVIAN; SILVA, 2007; MARCONI; LAKATOS, 2017; PÁDUA, 2004). Indicating that "the search for a true explanation for the relationships that occur between facts, whether natural or social, passes, within the so-called theory of knowledge, through the discussion of method" (PÁDUA, 2004, p. 16). About this, we found that

> method is the set of systematic and rational activities that, with greater security and economy, allows achieving the objective of producing valid and true knowledge, tracing the path to be followed, detecting errors and helping the scientist's decisions" (MARCONI; LAKATOS, 2017, p. 79).

In addition to these general definitions of methods, the authors also point out that "the sciences are characterized by the use of scientific methods, but not all branches of study that employ these methods are science" (MARCONI; LAKATOS, 2017, p. 79), indicating that, although the presence of a method is a requirement for doing science, it alone is not capable of delimiting it.

Despite the recurrent reference that a method is a distinctive criterion of science, in practice, the delimitation of the frontiers of science — when comparing the areas that explicitly adopt quantitative methodologies (closer to the natural sciences) with those that adopt qualitative methodologies (closer to the social sciences)—would not be as clear. Even if one agrees with Kuhn (2011, p. 197) when, referring to the area of physics, he states that "an intense qualitative work has generally been a condition for a productive quantification in the physical sciences", one must consider that such conclusion would not be intuitive or current in training courses in the area. Added to this, even though when talking about science "it is normally accepted that one is talking about Physics, Chemistry and Biology and related fields" (MOREIRA; MASSONI, 2011, p. 8), it happens that, "when you use qualifiers, it is common to identify Economic Sciences, Political Sciences and even Theological Sciences as fields of scientific knowledge" (MOREIRA; MASSONI, 2011, p. 8). This aspect makes the attempt to establish common demarcation criteria for different areas even more difficult.

One way out to define this demarcation would be to resort to the definitions of philosophers of science to solve this problem. However, even simple practices show that, among students, there is no alignment with a single epistemologist (SILVA *et al.,* 2018); in fact, not even among philosophers of science is there a consensus on the demarcation of science. Thus, a safer position would be to agree with Piaget (1967, p. 51): "epistemological reflection emerges more and more within the sciences itself", and not in positions external to each area. In terms of analyzing the methodologies and practices used by each area to identify them as scientific, this means starting from the position that "the idea of a method that contains firm, immutable and absolute mandatory principles to conduct the business of science faces considerable difficulty when faced with the results of historical research" (FEYERABEND, 2011, p. 37), whether looking at the history of an area in a linear way, or looking at its branching processes.

When dealing with the analysis of scientific work in each area, however, it is important to note that, even if one gives up the existence of rigid laws that guide the sciences and assumes a position according to which "science is an essentially anarchic undertaking" (FEYERABEND, 2011, p. 31) and that "there is not a single rule that remains valid in all circumstances, nor a single means to which one can always resort" (FEYERABEND, 2011, p. 208), this does not mean to be necessary to reject the idea that each area should have its own structure. On the contrary: it is unreasonable to expect that all areas share the same structure, not least because "the standards we use and the rules we recommend only make sense in a world that has a certain structure. In a domain that does not exhibit this structure, they become inapplicable, or work occasionally" (FEYERABEND, 2011, p. 296). That is, the fact that more than one area categorically states that it does science, but with different procedures, instruments, ontological and methodological foundations, does not consist of mistakes on either side. What happens is just the existence of distinct understandings for objects that share the same name, pointing to what

Kuhn and Feyerabend — each in their own way (OBERHEIM, 2005) — describe as incommensurability.

In reviewing his own work, Kuhn makes the following comment about incommensurability:

> Most readers of my text assumed that by speaking of theories as incommensurable, I meant that they could not be compared. [...] In applying the term "incommensurability" to theories, I meant only to maintain that there was no common language in which these theories could be fully expressed and which therefore lends itself to a point-by-point comparison between them. (KUHN, 2006, p.233).

In this way, the role that Kuhn attributes to the concepts of each area is linked to the idea that “each member of a community has a lexicon, the module that contains the species concepts of that community, and, in each lexicon, the concepts of species are coated with expectations about the properties of their various referents” (KUHN, 2006, p. 296). Thus, “as Kuhn repeatedly stressed, acquiring a new scientific lexicon is equivalent to learning a new language: it requires bilingualism, not translatability” (MASSIMI, 2015, p. 87), as it is about recognizing not only the meaning of a new term, but its internal connection with the other terms shared by the community.

A first direct implication of this is that the conception that each area has about any term — including the term science — is particular and contextual to it. A second implication is that, in terms of translation and interpretation, the ability to carry out translations is individual and not collective, that is: no matter how well a bilingual subject (fluent in two fields) transcribes concepts from one area to another in an intelligible way , what the other members will be able to do with such transcriptions will be, at most, an interpretation very close to the original meaning, but never a faithful translation, as they lack mastery of the original lexical structure. Therefore, the property to defend the concepts and interpretations of an area is of primacy of the area itself. This claim is recurrent in Mayr's (2005) epistemology directed to Biology, as well as in human science epistemologies defended by its proponents (LE MOIGNE, 1995).

Still on the demarcation criteria between the scientific and the non-scientific, what is observed is the existence of different criteria. Such differences do not only occur between areas, but also between different philosophers of science (HIRVONEN; KARISTO, 2022). While Popper (2013, p. 37) identifies falsifiability as a demarcation criterion, Kuhn (2011, p. 191) states that, if the demarcation exists, it must be positioned in the resolution of enigmas. Lakatos (1978, p. 25), in turn, places the demarcation in the empirical basis of theories, and Laudan (2011, p. 20) casts doubt on his own existence of a well-defined border between the scientific and the non-scientific. This again indicates the role of the areas themselves in defining them.

Having established the primacy of each area to build their views on their scientific practices, it remains to define constructive and shared criteria (or at least principles) that explain the construction of the areas. Kuhn, at different times, points to the role of manuals and the recurring exposure to exemplary models, as well as addressing the role of teachers themselves as delimiters of the views that will be had on scientific doing (KUHN, 1982, 2006, 2011). Laudan, in turn, despite not believing that scientific and non-scientific problems are fundamentally different (LAUDAN, 2011, p. 20), makes the demarcation of science more flexible. Even so, it brings a distinctive feature to science: the existence of a main audience to which research is directed and by whom it is evaluated (LAUDAN, 2011, p. 132). With respect to the main public, even though Kuhn does not use the term itself, he relates the emergence of a new paradigm, which would be the acceptance of ideas proposed in journals that fulfill this role (KUHN, 1982, p. 40).

Another point that crosses the different epistemologists is the question of the researcher having the purpose of research to convince the community — despite different emphases being adopted to promote this conviction. Popper (2013, p. 242), for example, takes as a basis for convincing the performance of experiments that falsify statements followed by theories. Kuhn (1982, p. 40), in turn, delegates to textbooks this formative role in convincing the community of normal scientists. Feyerabend (2011, p. 99) attributes this role to rhetoric and propaganda, while Laudan (2011) focuses on the problem-solving capacity of sets of theories in order to convince the public.

ANALYSIS METHODOLOGIES FOR COMPARISON BETWEEN DIFFERENT AREAS

When thinking about the possibility of dialogue between the areas and considering the existence of differences in the way they describe their research objects, it remains to identify elements that are comparable and important for each area. One way to do this is to use data analysis methodologies that favor the construction of readings that are as contextual as possible. This is the case of Discursive Textual Analysis (DTA), by Moraes and Galiazzi (2016), which argues that discourse analysis should be carried out taking into account not only fragments, but totalities. This must be done through a process composed of four successive and cyclical steps: i) dismantling the texts; ii) establishment of relationships; iii) capture of the new emerging market; and iv) a process of self-organization (MORAES; GALIAZZI, 2016).

A differential of this methodology is that it considers that

> the interiority of thought and the exteriority of the word constitute a unit in which it is not possible to determine a precedent. The perceived and the spoken constitute a single plane, given that objects only acquire their meaning through language (MORAES; GALIAZZI, 2016, p. 28).

That is, thought and language would be intertwined in such a way that, by taking into account the relationships between words and their different units of analysis, it would be possible to have access to the very relationships constituted on the object of his speech. Within the DTA, the approximation to the meanings occurs in a deeper way with each revisit to its units of analysis, since each revisit allows the identification of new interrelationships.

For the comparisons made in this research, 63 interviews conducted through the Google Meet video call platform between August 2021 and March 2022 were analyzed. The invited participants were the students of the five offered courses offered in four of the six units of Region II of the UERGS (the other units did not participate in the research because their course was already represented, or because it is geographically distant from the others, which would make face-to-face intervention difficult, if necessary). The interviews were of the semi-structured type, with a script with objectives to be achieved in different areas, but with the possibility of making the questions to be asked more flexible in order to achieve the objectives.

In terms of the number of invitations and participants, at first around 175 invitations were made to each course, however, as the desired membership (20 participants per course) was not achieved in the Environmental Management and Pedagogy courses, made it necessary to invite more participants from other units. In this way, it was possible to increase the number of guests from Environmental Management to 242 and from Pedagogy to 225 (in this course, contact was also made with a third unit that offers it, but with no response). At the end of the invitation processes, 21 participants from Agronomy, 15 from Food Science and Technology, 14 from Bioprocess Engineering and Biotechnology, eight from Environmental Management (of which two were from the second round of invitations) and five from Pedagogy (from which one was from the second round of invitations). Bearing in mind that data collection took place through interviews, it was necessary that, before they were carried out, the project was analyzed and approved by the Research Ethics Committees of the institutions involved (UFRGS and UERGS), having been approved in both, with CAAE 48745721.9.0000.5347.

In a practical and objective way, the adoption of the use of DTA in the analysis of these interviews is due to its potential that, even not being able to completely break with the incommensurability between the areas to be compared — since it brings not the only, but a possible interpretation for the relationships —, it allows, through its proposal of integral and cyclical analysis of the discourses, a reading of the concepts in a way related as much as possible to a background context, which re-signifies the readings and interpretations. Thus, if on the one hand the DTA does not allow a point-to-point comparison between areas; on the other hand, it makes it possible to identify common relationship axes formulated by the areas. Therefore, it enables the inference to greater or lesser approximations between the thoughts in each area.

Regarding the comparisons to be made, when two or more areas are placed side by side, there will obviously be an infinity of points that can be compared. Not all, however, will offer the same possibility of deepening. Considering the DTA methodology as an instrument for discourse analysis, it offers two opposite (but complementary) paths to be followed in discourse analysis. A first path is to establish, a priori, categories and/or references to be used to analyze the discourses. A second way is to collect the statements and, as they are revisited, look for categories and/or references to understand them (MORAES; GALIAZZI, 2016, p. 95). The first path has the advantage that, from the beginning of data collection (interviews), one already has an idea of what to expect both in terms of responses and the references to be consulted to interpret them. The second path has the advantage of a greater possibility of interrelationships and greater ease of identification of meanings emerging from the discourses.

In the case of this research, in which the interviews were conducted by someone with the reading of different epistemologists, the initial classification of the themes was, to a certain extent, a priori, based on the comparisons of the epistemologists themselves. Thus, for conducting the interviews, six main themes were chosen for the research, of which the present work will focus on the first two, namely: i) general data of the interviewees, such as the name of the course, stage of training and previous experience in research, monitoring and extension activities; and ii) characterization of views on the areas themselves, based on the fact that the reading of different epistemologists allows very different interpretations about very similar objects and terms.

In addition to these themes, the interviews sought statements in four other areas, which, as a result of the use of the DTA, at times were related to the two previous ones — even if they will not be deepened in this work. They are: the role of experimentation within each area; research on understanding the structure of each area; the weight of elements external to science — such as political, social and economic issues — on each area; and, finally, the search for particularities and exclusivities of each area.

If, at first, the themes of the interviews were established a priori, in a second moment, when focusing on each of the areas, new emerging categories were sought through re-reading and comparison of the interviews. Thus, within the theme of characterizing the students' views on the constitution of science in their own areas, the statements were analyzed and compared within three categories: i) how science is done in each area and what would be a typical research for to each area; ii) what is the role of statistics within each area; and iii) the possibility of carrying out, within the areas, research generally related to the human sciences.

COMPARING AND DISCUSSING AREAS

The first category of units of analysis sought in the participants' speeches was related to how science is done and what is typical research for each area (Chart 1).

Chart 1 – Units of analysis that deal with the question of how science is done in each area and what would be a typical research for each area.

	Agro	FST	Bio Bio	EM	Ped	Tot
Comparison of treatments to see the best	1	0	0	0	0	1
Something you don't have to work with people	0	1	0	0	0	1
Practical application of theoretical studies	0	0	0	0	1	1
Research as a means of controlling variables and making predictions	2	0	0	0	0	2
Something that also takes into account the human aspects	0	0	0	1	3	4
I didn't know how to answer	1	1	2	1	0	5
something made in the field	0	0	0	6	0	6
The area is very wide, there are different research possibilities	3	1	4	1	0	9
Something connected with laboratory analysis	0	4	6	1	0	11
Something that seeks innovation and presentation of new and relevant information for the area	13	6	4	0	1	24
It is based on the area in which you have already done an internship or Final Paper	13	8	4	5	2	32

Source: Research Data (2022).

Caption: Agro: Agronomy; FST: Food Science and Technology; BioBio: Bioprocess Engineering and Biotechnology; EM: Environmental Management; Ped: Pedagogy; tot: total.

One of the points that most stands out regarding the theme of the first area is that, immediately, 32 of the 63 participants related typical research in the area with what they had particularly worked on in internships or in the Final Paper. Furthermore, of the 31 participants who did not make that connection, 16 are at the beginning of the course. Result that, when confronted with the epistemologists, allows some relationships. A first relationship is with Laudan's position that *"unresolved problems are only considered genuine when they are no longer unresolved"* (2011, p. 27) (original italics). Thus, it can be said that it is through immersion in the ways of solving problems within a field — which comes from practical experiences — that one begins to build one's own vision in terms of the area's identity. A similar position is brought by Kuhn: even if, at first, the students' bond takes place through the appropriation of didactic manuals and teachers' positioning (KUHN, 1982, p. 111), in a second moment, it is by experiencing different exemplary practices that one acquires the effective insertion and capacity of operation (KUHN, 2006, p. 224). Similar propositions are equally abundant when discussing the importance of the active role of students in their own learning (ASSUNÇÃO, 2021; LEITE; RODRIGUES; MAGALHÃES JÚNIOR, 2015; SANTOS *et al.,* 2022).

With regard to linking research typical of the area to what is already practiced in stages, it should be noted that this has the direct consequence that, even within the same area, science can be typified in different ways. This ends up breaking with the paradigmatic rigidity initially established by Kuhn (1982, p. 14) and repeatedly questioned by Lakatos (1978, p. 92), Laudan (2011, p. 103) and Mayr (2005, p. 144).

Still on the construction of a vision about the area itself, it is noteworthy that nine students indicated that, due to the breadth of their areas, it would not be possible to point to a single type of research as typical. Of these, five spontaneously reported the influence that specific teachers had on their conception of the breadth of science. Another three students reported having completed, at least partially, other graduations in areas not so close, but with which they found some connection. The fact of spontaneously and nominally citing a teacher as a reference indicates, at the very least, that this teacher has played an important role in the individual training of the participant.

Different relationships can be made between epistemologists and these data. Starting with Kuhn (2006, p. 150), who, in his last writings, visualized in the dialogue between the areas a privileged situation for the construction of new disciplinary matrices. Laudan (2011, p. 121) admits the possibility of different configurations between theories and research traditions, since *"there are many incompatible theories that can claim to belong to the same research tradition, and there are many different research traditions that can, in principle, provide the basis of presupposition for any theory"* (original italics). This occurs in such a way that, when thinking in terms of individual understanding of an area, one must take into account the subject's entire formative base. This is a somewhat different thought from that of Kuhn (1982, p. 222), who, even considering that "in general, individual scientists, especially the most capable ones, will belong to several of these groups, simultaneously or in succession", maintains a both the limits of each area are closed — even in cases where the researcher is versed in more than one area, because "as Kuhn repeatedly stressed, acquiring a new scientific lexicon is equivalent to learning a new language: it requires bilingualism, not translatability" (MASSIMI , 2015, p. 87). Feyerabend (2011), in turn, points out that it would be possible to make a relationship with the very propositions of methodological diversity that permeates the entire work *Against the Method*.

Now, thinking about the explanations about the possibility of transit between areas or even within the area itself, Kuhn (1982, p. 222) precisely indicates that the concomitant insertion in more than one area or subarea is an individual capacity, which is mediated by the formative instruments or actors. Thus, the expectation is that, if students have access to more specific views of their areas during their training, they will replicate them. As they have access to a diversity of research possibilities, the expectation is that they will be able to perceive their own area in a broader way. Still within the same line, Kuhn, Feyerabend, Laudan and Bachelard consider that the great advances in the areas usually come through researchers with certain specific characteristics, such as: ability to question their methods (FEYERABEND, 2011), their conceptual bases (LAUDAN, 2011) and often seek development in the discussion (BACHELARD, 1978).

Seeking now to characterize each area contemplated in the present study, it is observed that, within Agronomy, the idea of research is closely linked to the search for innovation or improvements (13 of the 21 interviews). A student at the end of her course, when asked about typical research in her area, highlighted this point objectively: “improvements for agriculture or livestock, which is what I experienced the most”. Similar ideas were found within Food Science and Technology (six out of 15 interviews): “when I say this in research, effectively in the area, I imagine methods and ways to improve processes”. Still within Food Science and Technology, there is a link between science and laboratory work (four out of 15 respondents), an idea shared with Bioprocess Engineering and Biotechnology (six out of 14 respondents): “look, to be quite honest, I imagine a very similar to the movie, you know? The laboratory, people researching, the same was the issue of covid, then they take it and discover the genome and research for a vaccine begins”.

In the area of Environmental Management, the most prominent connection (six out of eight interviewees) was between science and field work: “generally, I see it like this, a field trip where you are with your colleagues or with your advisor and you start discussing a certain subject and you find a problem or you involve or develop a project with the community”. Finally, within the area of Pedagogy, despite the low number of participants, the relationship that was made was, for the most part, with research with humans (three out of five interviewees), something consistent with the fact that the course is closer to the areas of human sciences.

Observing each of the characterizations of the areas in parallel, it is possible to perceive something already pointed out by Piaget (1967, p. 51) and reiterated by Le Moigne (1995, p. 19): however much one can take as a basis the visions that other areas have about science to understand the area itself, this may be insufficient. It is necessary that each area adheres to its particularities when thinking about its overlaps and borders with other fields.

At this point, it is also interesting to note that the areas in which the explanations of science were most avoided in terms of improvement and laboratory research were those that had the least adherence to research. This is due to the consideration of science from a more quantitative and comparative perspective. This idea is explored in the following units of analysis, which linked to the role of statistics and experimentation within each area (Chart 2).

With respect to the data in Table 2, a first perceptible unit was the speeches that, without statistics, it is impossible to carry out research within the area (32 of the 63 interviewees). This is a preponderant position among participants in Agronomy, Food Science and Technology, and Bioprocess Engineering and Biotechnology. This became evident when a student was asked if "in the case of Bioprocess Engineering and Biotechnology, is it possible to carry out research without resorting to statistics?". As an immediate answer, she said "surely not, never, never, never, ever!". Among the reasons raised for the need to use statistics in different areas (except Pedagogy), it was pointed out that, even without depending on statistics for the initial stages of a research, without it there is no way to make comparisons, just as it is not possible to attribute confidence in the data (27 of the 63 respondents).

Chart 2 – Units of analysis that deal with the issue of the role of statistics within each area.

	Agro	FST	Bio Bio	EM	Ped	Tot
Based on the internships and disciplines he took, the statistic is in all research in the area	3	0	0	0	0	3
Even without the use of statistics, it is important to resort to experimentation	0	0	0	0	3	3
Data as a synonym for numbers	4	6	3	0	0	13
The use of statistics is the traditional one, but you can do other research when you go to the humanities	8	2	2	1	0	13
It could be done research without using it	0	0	4	4	5	13
Statistics is essential, because without it it is not possible to make comparisons or have reliability, even if the initial research does not depend on it.	7	8	9	3	0	27
It is not possible to do research without statistics within the course	12	8	10	2	0	32

Source: Research Data (2022).

Caption: Agro: Agronomy; FST: Food Science and Technology; BioBio: Bioprocess Engineering and Biotechnology; EM: Environmental Management; Ped: Pedagogy; tot: total.

Drawing parallels with the epistemologists, it is relevant to note that, despite the results indicating a strong link between the interviewees between their areas and the obligation to use statistics to carry out research, this primacy of statistics and the quantitative is not necessarily followed in epistemologies. Popper (2013, p. 366), for example, presents the position that

> [...] science does not have high probabilities as its primary objective. It aims to achieve a high informative content, well supported by experience. However, a hypothesis can be very likely simply because it tells us nothing or because it tells us very little (original italics).

Kuhn (2011, p. 197), on the other hand, at a given moment, considers that "an intense qualitative work has generally been a condition for a productive quantification in the physical sciences", but without such knowledge reaching the students. Bachelard (1996, p. 259), in turn, identifies quantitative knowledge and its quest for precision as a possible obstacle to the advancement of science, while Laudan (2011, p. 91), in his valuation of the weights of conceptual problems in relation to to empirical ones, also points, as a rule, to the greater weight of conceptual problems over empirical anomalies. Considerations that, given the results of the interviews, reiterate the need for science to be constructed in a more critical way and with a greater historical basis.

Still in relation to the previous question, some interviewees share the understanding that, even if the use of statistics is traditional, there would be the possibility of carrying out research without using it, as when working with social science methodologies (13 of the 63 interviewees). Furthermore, there were also responses pointing out that it would not be mandatory in general (13 of the 63 respondents), which were more frequent in Environmental Management and Pedagogy courses, but also appeared in Bioprocess Engineering and Biotechnology.

Contrasting with previous positions, another common unit was the exclusive association of the term “data” with numbers, considering quantitative research as the only type of research possible to be done (12 of the 63 participants). This was expressed, for example, by an Agronomy student: “a lot of people question data, right? A lot of people like to work with data. Me too, I like to see numbers, I often don't know how to interpret them, but I like to see numbers, data, right?”, showing, again, the presence of a structure that is somewhat rigid, which he defines as an area may or may not be structured. The explanation that Kuhn (2011, p. 209) gives for the valuation of numerical data is related to the students' own training, during which problem solving takes place via manuals, making use of calculations in an uncritical and decontextualized way.

Regarding the use of the term “data”, it is interesting to note that, although part of the students associate it with the idea of numerical representation, this data can be anything, as long as it is recordable in a database and brings with it semantic relationships. (meaning) and pragmatic (normative) (FRICKÉ, 2015, p. 652). Furthermore, it is also essential to understand that, when it comes to data and their readings, “the central point is that the data do not speak. What is required is a huge amount of background knowledge, or assumptions, or prior research of one kind or another” (FRICKÉ, 2015, p. 654). This means that, in practice, it is necessary to adopt as a requirement for any use of information considered given the search for pre-established conceptual knowledge, as well as the subsequent presentation of interpretations and reasoned readings. Such an approach of inseparability between data and their explanations and the denial that data can be treated simply as a number are aligned not only with the criticism already pointed out in Kuhn, but also to Feyerabend's (2011) views of inseparability between data, discovery and justification contexts, due to the great possibility of subjectivation when methodologies are delineated and results are interpreted.

Opposing the idea that research could only be done through the use of statistics, participants were asked about the possibility of carrying out, in their research areas, the use of methodologies more common to the human sciences (Chart 3), such as case studies or ethnographic research, having previously been exemplified.

Regarding the use of methodologies more common to the human sciences, the predominant position (34 of the 63 interviewees) was that these methodologies would be viable within each area, provided that in situations or with specific audiences. The fact that there were 15 overlaps between this unit and that of those who stated that it was impossible to carry out research without the use of statistics within the area was noteworthy. That is, 15 interviewees stated both that it is impossible to do research without using statistics, and that, depending on what you want to research, it is possible to research only using social methodologies. In this sense, one of the statements that drew attention was from one of the participants, who, when discussing the role of statistics and the use of test and control groups, stated: "I think this is the basis of most research in the field of bioprocesses and biotechnology, this is extremely... like, it's necessary. Mainly comparing what was found with other works, you know?". Then, when talking about the possibility of using social research, he stated: "I believe that in certain matters, yes, for example, today I work in the health area, [...] in this area of health, I apply the knowledge of biotechnology, however, has this approach, more behavioral and anthropological". What draws attention in this case is that, even already working and researching in the area with a more social bias, the image that remains for the subject in relation to his area is still linked to the need to use statistics.

Chart 3 – Units of analysis that deal with the question of the possibility of carrying out, within the areas, research generally related to the human sciences.

	Agro	FST	Bio Bio	EM	Ped	Tot
Don't know how to answer	1	0	0	0	0	1
There is the possibility of review surveys, which, to some extent, accept the opinions	1	0	1	0	1	3
The way science is done in different areas is very similar	1	1	0	0	1	3
Don't see the possibility	3	2	1	0	0	6
Field surveys must be opinion-free or controlled; therefore, these methodologies do not fit	4	2	1	0	0	7
Human sciences are important for expanding the field of research in the area	1	2	3	1	0	7
Could see in any discipline that it is possible and how it can be done	0	5	1	2	0	8
Information from the social sciences or opinionated serves as a learning methodology or guidance, but not as research	9	4	4	1	0	18
There is the possibility when studying a specific population or situation	8	8	11	6	1	34

Source: Research Data (2022)

Caption: Agro: Agronomy; FST: Food Science and Technology; BioBio: Bioprocess Engineering and Biotechnology; EM: Environmental Management; Ped: Pedagogy; tot: total

The existence of such contradictions in the discourses points to a need for greater promotion of moments of reflection within the areas themselves, rather than the search for external epistemological bases — which is something already indicated by Piaget (1967, p. 51). In terms of the structure of the areas, these contradictions come to support Laudan's view (2011, p. 64) that, sometimes, in science, one works with contradictory systems, also supporting his view that these problems of lack of coherence often does not receive due attention. At the same time, the observation of such contradictions also allows dialogue with Lakatos' proposal (1978), according to which, in an investigation program, there would be elements armored against attacks, which would constitute the hard core of the theory (in this case, linked to the use of statistics), while other elements would have the function of providing a positive heuristic linked to the delimitation of methodologies that can be used in order to carry out discoveries (in this case, social methodologies in specific situations).

As indicated in previous paragraphs, the reasons for this apparent contradiction may lie in considering that statistics are important for the final results, but not necessarily for the initial results of the research, as highlighted by another EBB student: “Ah, I think that to make it easier, it is resorting [to statistics] is essential, but if you want to start from scratch, have a little more work, I think you can guide yourself without that part”. Such a prominent view of qualitative approaches as a prerequisite for the use of statistics, as already presented, finds support in Kuhn (2011, p. 197). On the other hand, one should take into account the role that dialogue between areas can play in the development of new theories. This is something presented in the construction of research traditions in Laudan (2011), pointed out by Feyerabend (2011) as a way of developing new methodologies and indicated as a key characteristic of revolutionary scientists, who would still be able to move between areas for not having strengthened their links with any specific paradigm (KUHN, 1982).

Other positions similar to the previous ones formed a unit with discourses that the social sciences serve for the formation of the subject or for the contextualization of research, but do not function as individual research, in part because they are not free of opinion (18 of the 63 interviewees). However, the view that science is free of opinions or subjectivities finds no basis in Laudan (2011), is questioned by Kuhn (1982, p. 13), is questioned by Bachelard (1996, p. 305), is harshly criticized by Feyerabend (2011) and even collides with Popper (2013), when he talks about psychologism as a research motivator. This indicates the importance of introducing such reflections to students in training, so that they have a better understanding of the dynamics of the functioning of their own areas.

Another statement that drew attention was that of an Environmental Management participant when he explained what research in the area would be like without the use of statistics: “Without statistics there [would] say: ah! The plant stayed there..., it got a little drier, a little calmer there, but it didn't give much, I'll remove everything. No, I don't think so, it doesn't work”. Here, the use of the diminutive (in Portuguese language) indicates the existence of a certain hierarchy between qualitative (infantilized) and quantitative (mature).

On the other hand, two other units that drew attention were those that highlighted the role of human sciences in expanding the research fields in their own area (seven out of 63 participants) and the students who, from the beginning, brought a more conciliatory view between the areas, justifying that, throughout their courses, they would have participated in specific disciplines that sought to propose these reconciliations (eight of the 63 participants). One of the statements that highlighted the indissociability of the area with the human sciences was given by a final-year student in Agronomy:

> today we cannot see agriculture without people, it is impossible, both in terms of survival and in terms of work. [...] no one produces food just to say they have productivity and money. Someone has to eat this, right?

Another possibility was brought up by a recent entrant in Food Science and Technology when talking about the research objects: “we don’t necessarily have to talk about the subjects of the disciplines themselves, we can talk about the issue of the professional’s performance”.

About the eight conciliatory speeches that brought the information obtained in a discipline, they demonstrate that a way to broaden the views on science comes precisely from the training of the teachers themselves within the areas and the attitude of these teachers as educators. In this sense, even if epistemologists point out that scientific training is not always one of the teaching focuses of teachers, it occasionally appears at different times. The Argentinean Mario Bunge (1980, p. 80), for example, when speaking of the challenges facing universities, indicates that “the university in the Third World suffers from three great evils, among many others: the insufficient preparation of its students, the improvisation of its teachers and the politicization of its students and teachers”. Such points — at least in part, as suggested by the interviews — can be resolved through teacher qualification. Feyerabend (2011, p. 21), on the other hand, when speaking of science education, states that “in cases where the work of scientists affects the public, the public would even *have an obligation* to participate: first, because it is an interested party [...]; second, because such participation is the best science education the public can get” (original italics). Thus, some of the gains of including human aspects within the sciences are indicated.

Regarding the impacts of teachers on the scientific training of students, Bachelard is even clearer, explaining the relevance of explaining the processes.

> Undoubtedly, it would be easier *to teach only the result*. But teaching the *results* of science is never scientific teaching. If the spiritual production line that led to the result is not explained, you can be sure that the student will associate the result with his best known images. It is necessary "that he understand". You can only keep what you understand. The student understands in his own way. Since he was not given the reasons, he adds personal reasons to the result. It is easy for a professor of physics with a little psychology to see – with regard to the problem dealt with here – how an unexplained intuition ‘matures’. (BACHELARD, 1996, p. 289) (original italics).

Despite the high number of participants who indicated that human sciences methodologies were acceptable in their areas to some extent (34 out of 63 participants), when the subject was the area's reception to this type of research, a considerable part of the students reported that they would cause strangeness within the area (19 of the 63 participants). Of these students, 13 had previously reported the possibility of using them within the area. These positions end up reinforcing the very view of formal rigidity of disciplines within disciplinary matrices or even paradigms, that is, even if it is possible to make conjectures outside the limits of the area, there would be well-defined limits of what is or is not acceptable for the area. Depending on the epistemologists, these limits would be defined by journals and manuals (KUHN, 1982), by the existence of main audiences (LAUDAN, 2011), by the definitions of foreign scientific communities represented, by journals of relevance to the areas (BUNGE, 1980) or even for reasons of rhetorical and propaganda ability (FEYERABEND, 2011).

CONCLUSION

Returning to Moreira and Massoni's (2011) initial proposals of presenting the different epistemologies to their readers, and now making it possible to draw a parallel with the conceptions of students from different courses about what science is and how science is done, it is clear that only the diversity of explanatory lines among epistemologists, but also the diversity of conceptions between courses — or even within courses. This diversity of opinions is something natural, being permeated by issues peculiar to each area, issues of subject formation and other causes. It does not mean, however, that the areas are completely isolated or even that they cannot be compared in some respects.

Thinking about the structure of each of the analyzed courses and the way in which the students of each course describe their own area, it is possible to perceive, initially, that although the areas have different objects of analysis, sometimes the structuring elements of each research area turn out to be very close, such as the strong base and belief in the mandatory use of statistics in Agronomy, Food Science and Technology and Bioprocess Engineering and Biotechnology courses. Or the counterpart to this: depending on the objective, students think that there would be the possibility of carrying out research through social methodologies even in these areas. Regarding how views on science are constructed, it is even more relevant the perception that the starting point for the definitions of what is typical research for the area departed, as a rule, from the participants' own subjectivity and practical experiences. , which, on the one hand, helps to understand the very diversity of views of epistemologists (since each of them has different experiences); on the other hand, it justifies positions such as those of Mayr, Piaget and Le Moigne, of encouraging each area to develop its own epistemology.

In terms of comparative analyzes between the courses, what was verified was that, despite the issue of incommensurability, DTA, when working with concepts within contextual frameworks, allowed, to a great extent, to overcome the barriers of incommensurability, allowing both the identification of different views within the same courses — which breaks with more watertight views, such as that one always works within rigid paradigms — as well as the identification of common elements even between more distant areas, strengthening the belief that, by go from one area to another, certain conceptual and methodological baggage is carried.

Thinking about the fluidity between areas, the situation of students who reported the influence of professors, training in other areas and disciplines from more distant areas on their own views regarding aspects of science is even more interesting. In this sense, it drew attention that the dialogue between areas allowed these participants to have a broader view of their field of research and, in particular, to envision new possibilities for their fields, indicating the richness that the dialogue between areas has both in personal training and in the enrichment of areas. This is defended at different times by Laudan, Piaget, Kuhn, Feyerabend and others.

CONCEPÇÕES SOBRE PESQUISAS QUANTITATIVAS, QUALITATIVAS E CONSTRUÇÃO DA CIÊNCIA ENTRE ESTUDANTES DE GRADUAÇÃO DA UERGS

RESUMO

A epistemologia, enquanto campo de estudo do desenvolvimento científico, encontra-se representada por diferentes filósofos da ciência, cada qual com seu próprio sistema de explicação para o desenvolvimento científico. Apesar da diversidade de opiniões emitidas por esses filósofos e do embate que muitas vezes travam entre si, o diálogo entre eles é possível e frutífero — desde que se faça uso de metodologias próprias e que levem em conta os contextos e as buscas de cada um. Dessa forma, com base nas contribuições de diferentes epistemólogos, o presente trabalho busca identificar a compreensão de aspectos-chave das ciências junto a estudantes de cinco cursos de graduação da Universidade Estadual do Rio Grande do Sul (UERGS). Em termos metodológicos, a pesquisa pode ser considerada qualitativa, tendo em vista que a coleta de dados se deu por meio da realização de entrevistas semiestruturadas. Uma vez realizadas, as entrevistas foram analisadas por meio de um processo de análise textual discursiva, a qual classificou os diferentes posicionamentos dos estudantes em três temáticas principais: i) a forma como compreendem a ciência em suas áreas; ii) o papel que as pesquisas quantitativas tem em suas áreas; e iii) a possibilidade de realização de pesquisas qualitativas em cada campo. Cada uma dessas temáticas foi discutida a partir de referenciais epistemológicos. Como resultado, foi possível identificar diferentes entendimentos sobre o fazer científico, tanto entre os cursos, quanto dentro de cada curso. Também se percebeu que a estatística e os dados quantitativos têm um papel relevante para a maior parte das áreas, mesmo que seus usos e funções nem sempre sejam de total domínio dos estudantes. Por fim, verificou-se que, apesar de um número considerável de estudantes considerar possível a realização de pesquisas qualitativas dentro de suas áreas, poucos souberam dizer como esse tipo de pesquisa poderia ser instrumentalizada ou se elas seriam facilmente aceitas por suas áreas.

PALAVRAS-CHAVE: Epistemologia. Filosofia da ciência. Formação discente. Ensino superior

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Received: Sep. 14th, 2022.
Approved: Jan. 27th, 2023.
DOI: 10.3895/rbect.v16n1.15951
How to cite: BRAUNSTEIN, G. K.; DEL PINO, J. C. Conceptions about quantitative and qualitative research and the construction of science among undergraduate students at UERGS. **Brazilian Journal of Science Teaching and Technology**, Ponta Grossa, v.16, p. 1-21, 2023. Available at: <https://periodicos.utfpr.edu.br/rbect/article/view/15951>. Access on: XXX.
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