Analysis of epistemic practices in reports of higher education students groups in carrying out the inquiry-based activity of immunology

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ANALYSIS OF EPISTEMIC PRACTICES IN REPORTS OF HIGHER EDUCATION STUDENTS GROUPS IN CARRYING OUT THE INQUIRY-BASED ACTIVITY OF IMMUNOLOGY

Análise das práticas epistêmicas nos relatórios de grupos de alunos do curso superior durante a execução de uma atividade investigativa de imunologia

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Abstract

Practical classes in immunology are important to assist the learning of abstract theoretical concepts of biological phenomena learned in the classroom. Here, our proposal was the qualitative characterization of epistemic practices. Analysis of the results obtained from the investigative activities showed that student groups mobilize a huge variety of epistemic practices during reports writing, for example, to predict, conclude, name, describe, explain, opine, and the use of theoretical data for reviewing and evaluating the consistency of the data observed. A better understanding of these interactions can help in the teaching of Immunology classes for undergraduate students of life sciences and health courses.

Keywords: Epistemic practices; Teaching immunology; Teaching biology; Inquiry-based activity.

Resumo

As aulas práticas em imunologia são importantes para auxiliar a aprendizagem de conceitos teóricos e abstratos de fenômenos biológicos aprendidas em sala de aula. Aqui, nossa proposta foi a caracterização qualitativa das práticas epistêmicas mobilizadas por alunos de graduação em uma atividade investigativa. A análise dos resultados das atividades de investigação realizadas mostrou que grupos de estudantes mobilizam uma variedade de práticas epistêmicas durante a elaboração de relatórios, como por exemplo, prever, concluir, nomear, descrever, explicar, opinar, o uso de dados teóricos para a revisão e avaliar a consistência dos dados Uma melhor compreensão dessas interações pode ajudar no ensino de Imunologia para alunos de graduação de cursos da ciências da vida e da saúde.

Palavras-Chave: Práticas epistêmicas; Ensino de imunologia; Ensino de biologia; Ensino por investigação.

INTRODUCTION

Our interest in this study is to scientifically evaluate the development of an educational activity for higher education students during Immunology classes; the main purpose of that is to coordinate and allow the students' exposure to practices and languages of science. Thus, our first approach here was to expose our theoretical affinity in the field of teaching science that addresses the main studies on the epistemic practices in science classroom.

Teaching activities concerning investigative proposals focused on solving problems and not only the execution of predefined protocols, encourage and provide better development of students skills being able to search and find relevant information for the realization of a particular activity; also, it develops the competence to evaluate new information and, consequently, to find scientific solutions to practical problems. This idea arised in the mid-70s as the opposite to the teaching and learning concept focus only in concepts and theories, where science is linked.

The school term for research is still permeated by discussions that touch different senses among researchers in the field of teaching methodology proposed here. This polyphonic making can be reflected in the different meaning of the concepts of research on the various methodologies for construction of knowledge in science. On the other hand there is also diversity in the construction of itineraries that include the structure of this educational proposal. However, since the 90s this science education approach is suggested to be included in school science curriculum by government agencies worldwide such as the American Association of Advancement of Science (AAAS) English Citizenship Education Longitudinal Study (CELS) and the Brazilian Educational Guidelines Complementary to the National Curriculum Standards of the Ministry of Education (MEC-PCN) (Sá, Lima & Aguiar, 2009; Smithenry, 2010). This proposal is in line with many ways of research organizations during science classes, and which can be guided by teachers or in result of an independent action of students involved in the activity (Rogers & Abell, 2008; Apedoe, 2007; Anderson, 2007). To seek a proposal of teaching by using practical research we start from the premise that knowledge in the natural sciences is built by an investigation that incorporates scientific methodology in making and analyzing data obtained from experimental activity, interpretation of results, propositions of formulation and conclusions about the natural phenomenon investigated. Thus, we consider that inquiry-based learning can be carried out by a work based on teaching ideas and learning science developed in the process of construction and reconstruction of scientific knowledge; it can be included for example in the context of scientific practice (by providing students the experience of scientific practice and forms as a scientist perform in his workplace) (Guisasola *et al*, 2007; Smithenry, 2010). Thus, the proposal of inquiry-based learning aims to provide the contact of students with the concepts of appropriation processes, epistemic and discursive practices of the scientific community of the natural sciences.

On the social practices of science, especially in search of epistemic practices in science education, several authors have focused on the teaching of science based on the epistemic practices for universal sciences (Kelly & Duschl, 2002; Kelly, 2008). It is understood by epistemic practices, the set of actions, languages and practices shared by the scientific community, such as the use of the scientific method, with its logical sequences, as practice in order to propose a knowledge or language practices, such as argument, relevant and part of communication and examination of the results by and from the members of this community. The set of practices that community use to the issues of teaching and learning in science education brings perspective as a tool for scientific literacy of young people and even to adults. Still focusing on studies of the use of epistemic practices in science education, it was developed a number of categories for the investigation of these practices based on the context of the classroom. Basically we can highlight three groups: production, communication and evaluation of knowledge.

Jiménez-Aleixandre *et al*. (2008), based on the proposals of Sandoval *et al.* (2000) and Kelly (2008) produced a set of categories for the evaluation of epistemic practices according to their link with the knowledge worked by students. Thus, these authors classify social relations practices of knowledge into three groups: production, communication, and evaluation of knowledge. For each of these parts, they propose the existence of general epistemic practices of science, that is, common to all scientific fields, and a set of specific practices, those related to the particular field of science involved in the study.

Our group has been using the analysis methodology to assess interactions between the students in biology classes with multiple foci, including on the issues of epistemic practices mobilized by students into the inquiry-based learning in biology classes and science teaching. Vieira, Trivelato and Manzoni-de-Almeida (2014) characterized the epistemic practices mobilized by high school students in the creation and development of biology experiments in educational classes for investigation. This analysis was concentrated on the question of knowledge production. Thus, their analysis showed students developed experiments by: a) formulating hypotheses, testing it using experimental models, and collecting results and formulating conclusions; b) the analysis of epistemic categories showed that greatest appearance of the category "questioning", i.e. the raising of questions for students; however into the students' speeches the category with greater appearance was the "Explanation", i.e. where the formulation, by means of experimental results, an explanation of the issues raised by teachers in the developed experiments. On the other hand, covering the production and communication of knowledge in his doctoral thesis, Silva (2015) showed the use of argumentation in communication and evaluation of knowledge. However, in the higher education field, this proposal still little explored can provide the contact of the students with the specific practices of science as well as a vocational training and engagement of actual scientific practice.

How important is the articulation of these proposals of science with specific teaching of biology taught in the scientific education of college students?

The Immunology is the branch of biology which studies the immune system and its interaction with all body systems complexity. It is a new area within biology. Immunology mainly aims to investigate the physiological functioning of the immune system of an individual in conditions of infection and no infection, as in cases of autoimmune diseases and hypersensitivity

Recently, Siqueira-Batista *et al*. (2009) showed an analysis of the concepts covered in the major textbooks on immunology and has brought question concerning on how the immune system works. The results showed the books analyzed had a single vision, in which the immune system is "militarized" and that its only function is to combat the body against invading microorganisms. As shown above, this release can be considered overcome by the context of other discussions have already been incorporated immunology and immune system function have already been plural, i.e., the recognition of pathogens, such as the homeostasis of the host. In this work, the authors bring to the light the discussion of an immunology teaching beyond the context "self" from "non-self" and the militarization of the immune system, and addressing other theories discussed in immunology.

Immunology has knowledge that are often abstract. The acquisition of this knowledge during immunology classes in higher education can be provided to the student from activities by research education. Thus, acquisition of knowledge is an active process , and learning self-dependent . So knowledge comes from learning rather than mere knowledge of facts , and thus the student is able to interact with their own doubts, bringing conclusion and application of knowledge obtained by them. In many cases, the undergraduate course physical space is the "border" between the production of knowledge in the university and the teaching of knowledge for professional scientific training. In that sense, Brazil is in seventeenth place of scientific production in the world; however, the scientific production of Brazilian Immunology occupies the eleventh place. In 1990, Immunology accounted for 5% of total output of the biomedical area in Brazil; in 1995, this picture was 9% (Barral & Barral-Neto, 2007). This scenario suggests there is interest in forming Brazilian scientists focused on the study of immunology. In Brazil, these scientists in immunology area begin to be formed from the graduate courses in the areas of life sciences and health.

Immunology is in full development and scientific research makes this more robust and complex knowledge leading the information contained in textbooks become outdated very quickly. Faced with this question of immunology teaching, a proposed solution to this problem cannot be based exclusively on increasing the volume or the transmission of knowledge efficiency. Teaching with a problematic proposed research activities, focused on solving problems and not on the execution of predefined protocols, encourages the development of skills and desirable attitudes as the ability to search and find relevant information to perform a specific job; and develops the ability to evaluate new information and ability to find creative solutions to practical problems.

This perspective is in line with the proposals on teaching by research science teaching area in primary school, with the goal of "scientific literacy", showing that the investigative nature of activities in science education should provide students not only for the manipulation of materials and tools to carry out practical activities, but for the observation data, the use of languages to communicate to others your chances and synthesis, the skills necessary for "scientific work" (Sasseron & Carvalho, 2011). Thus, working those skills needed scientific training, which can be developed within the higher education courses in the areas of biological and health.

In the specific context of Immunology discipline, a survey conducted by our group in 2013, during Basic Immunology discipline to two distinct groups of students of Pharmacy undergraduates and Biochemistry (data not yet published) showed that of all the points of content offered in the workload of the course, the subject of B lymphocytes and gene expression of the antigen receptors was the theme that students more pointed as a difficult topic to be understood, little learning and rejection of content. Another interesting fact of this survey was that 95% of students said they would like more practical classes during the course, placing them into a real context. Considering these facts, and given the problematic laboratory techniques for working a practical lesson on this theme, our question for this study was: how to work and develop an investigative sequence for on how the development of B cells and antibodies in immunology classes that address the Students' exposure investigative practices of the natural sciences?

Considering the proposal of education by research and the issues of a scientific area with well-known investigative bases, such as immunology, our research questions are:

1) Can we build an investigative activity that includes an abstract theme of immunology, and that is associated with mobilization of epistemic practices of science students in higher education?

2) What are the epistemic practices mobilized by undergraduate students in the execution of an investigative activity during immunology classes?

2) How students perform the articulation of epistemic practices with conceptual knowledge of immunology?

This study aimed to construct an investigative activity with an immunology theme, and also to study the issues of writing and oral language derived from interactions students in carrying out this activity in Immunology classes at the undergraduate and graduate degrees.

METHODOLOGY

The research sites

Basic Immunology discipline, this study participant was offered to the bachelor's program in Biological Sciences. The class consisted of 40 students enrolled full term on the fifth (5th) semester of the course of Biological Sciences and mentored by two teachers. Interested in the proposal of our project - development and study of didactic sequence of investigative nature of immunology - in corroboration to our scientific interests of our study, the discipline meet an audience of researchers in training in Immunology issues related to our activity investigative and by a potential to be future teachers in higher education in the areas of biological and medical of Brazilian public and private universities, conducted in collaboration with a special teaching discipline for application of didactic activity and collecting of part of our data. This course has a workload of 30 hours. The class of the discipline was composed of 16 students comprising masters and doctorate degrees. All information collected has been authorized by participants from the Term of Free Consent (TLC) previously signed. This study was submitted, reviewed and authorized by the local ethics committee before its performance.

The inquiry-based activity and its application during undergraduate classes and graduate Immunology classes

The inquiry-based activity

A complete description of the investigative activity was published in Manzoni-de-Almeida and Trivelato (2015). Briefly, the structure of investigative activity is divided into 3 parts. Part I is the presentation of the problem, and the question to be investigated. Part II is intended to contact, analysis of hypothetical data by students; here the students are encouraged to produce graphics and describe the observed data. Part III comprehends the development of the written conclusion. Thus, we developed a problem situation and a guided question for research in *Part I.* A researcher in the immunology laboratory has a mouse (B) with a chronic disease and another healthy one (A). He intends to transfer the animal bone marrow cells A to the animal B in order to test the therapy. In the first: three samples were collected from mouse bone marrow cells A. Before making the transfer the student needs to know the differentiation stage of the cell to be transferred. Cells of the 3 samples were subjected to analysis if: 1) there is the presence of IgM and IgD on the cell membrane; 2) cell responses to antigens (these two analyses performed by flow cytometry technique); 3) gene expression for RAG (these data were produced by PCR experiments); and 4) analysis of genes for immunoglobulin (these data were produced by Northern blot test). In *Part II*, each group of students receives a set of results obtained by experimental techniques they conducted and they will have to: 1) analyze the data; 2) describe the results; 3) complete the investigation by answering the question: "*in what differentiation stage are the cells in the sample they worked with?*"; and 4) based on their knowledge of immunology, justify the conclusion reached by the group. In *Part III* students have the opportunity to discuss the analyzed data and complete research in order to answer the question of the activity. All annotations and analyzed student responses were made in a so called "lab notebook".

Applications during undergraduate and graduate Immunology classes.

The inquiry-based activity was applied to the two student groups: one comprising students having degree in biological sciences, and another in a postgraduate course in biomedical area. There were differences in context between the disciplines of graduation and post-graduation. However, the theme, structure and trading conditions were the same for both groups. For the implementation of the activity, data set were divided into three categories according to the profile result that would be reached by the students:

1) Category A: data set to the result of characterization of the differentiation stage stem cells, or stem cell, the first stage in the differentiation of B cells, as well as all other cells of the immune system of mammals presented in the bone marrow;

2) Category B: data set to characterize the result of the pre-B cell differentiation stage, or one of the intermediate stages in the differentiation process of B cells in the bone marrow;

3) Category C: the data set to characterize total cell differentiation stage B, i.e., data that characterize a fully differentiated B cells in the bone marrow.

In the graduating class, the built investigative activity was applied inserted in a sequence of Immunology discipline of classes. The position of investigative activity in the teaching sequence was planned and built with discipline together with the teachers of the discipline obeying the subject worked in the activity. Thus, the investigative activity was preceded by five major themes of immunology to the concepts of differentiation and maturation of B cells: basic principles of immunology (basic concepts approach "definition of immunity", "specificity" and "immunological memory"); cells and organs of the immune system (definition of main cells [and functions] and organs of the immune system [structure and functions in the process of immune responses]); immune cell ontogeny (definitions of immune cells development processes [of the main molecules approach, receptors involved in this process]), and innate immunity (definitions of the concepts involved in the main cells classified in the innate immune system [macrophages, and dendritic cells]). The principles of laboratory techniques involved in investigative activity were inserted along these classes mentioned above as a result of exposure and definition of immunology concepts in class. The inquiry-based activity lasted 2 hours, matching the second half of the class 11 of the discipline. Students were divided into 12 groups with 5-6 participants per group. For each group were provided only one set of these categories containing the hypothetical data to be worked on investigative activity organized as follows: Group 1 through 4: The category data; Group 5 to 8: category B; Group 9 to 12: category C. Groups were not informed in which category were handling. The investigative activity was divided into three parts: 1) the presentation of the problem situation, and the question to be investigated; 2) analysis of the experimental data by student groups; 3) discussion, together with all other groups on the findings of each group.

In graduate class, the same investigative activity was applied also, as described for graduation classes. However, there were some changes in the instructional sequence of the classes, respecting the specificity of the course. The investigative activity was inserted in the lectures sequence of the graduate course. The position of investigative activity in the instructional sequence was designed; so before that the activity was discussed on the basis of education for research and further discussion on the activity. The investigative activity lasted 2 hours, corresponding to the second lesson of discipline. Students were divided into 6 groups with 2-3 participants per group. For the implementation of the activity data set were divided into three categories according to the profile result that would be reached by the students.

Data collection and analysis

Data collection

Data collection of both courses, in the undergraduate discipline of classes and in the graduate course of lectures, was given by analysis of the written reports ("lab notebook") produced by students in inquiry-based activity.

Analysis of the writings in “Laboratory notebooks”

Our goal with the analysis of texts in "Laboratory Notebooks" was the lifting of the appearance of the set of epistemic practices, evident in practical lessons reports of investigative nature, synthesized by Silva (2015) and inspired by the proposals of the social practices of science and scientific practices by Kelly (2008), Jiménez-Aleixandre *et al*. (2008) and Araújo (2008).

The analysis was performed by type of question: *Description* of issues and presentation of data, results rationalization, and conclusion of the analysis. The units of analysis for classification of epistemic practices were defined according to Del Corso (2014) “Brand”. For Del Corso (2014), each “Brand” is defined as a text run forming a paragraph or literary description (drawings, tables, architecture, graphics produced by the students). Here, we performed an adaptation considering a mark every structure of a sentence and paragraphs. In our case, for all matters only use the set Brands by phrases because there was no report on the appearance of literary inscriptions as defined above. After rating, each brand was analyzed for categorization along the lines of epistemic practices synthesized by Silva (2015) as shown in *Table 1.*

Table 1: categories of epistemic practices synthesized by Silva (2015)

Epistemic practice	Signification
Questioning	Create a question related to the topic being studied or resume a matter previously proposed by the teacher. Corresponds to the motivation to start a discussion.
Develop hypothesis	Elaborate possible explanation for a question or problem.
Making predictions	Can predict results based on the explanatory hypothesis.
Building data	Collect and record data.
Consider different sources	Resort to any data other than what is being worked on right now to solve the problem under discussion.
Conclude	Finalizing a problem or a question proposed.
Mention	Make explicit reference to those produced inscriptions, some knowledge of authority (teacher or specialized bibliography).
Describe	Discuss a system, object or phenomenon, in terms of characteristics of their constituents or spatiotemporal displacement of these constituents.

Explain	Establish causal relationship between observed phenomena and theoretical concepts, and /or implementing conditions of the experiment to make sense of this phenomenon.
Exemplify	Present theoretical model illustrated by specific data.
Opine	Presents a personal opinion, well signposted.
Conceptualize	Assign meaning to a concept explicit.
Generalize	Develop descriptions and explanations that are independent of a specific context.
Use data to theoretical evaluation	Present data to evaluate the theoretical statements.
Assess consistency of data	Ponder the validity of the data obtained.

RESULTS

Analysis of epistemic practices presence in the writings of "Laboratory notebooks" filled out by groups of undergraduate and graduate students

The analysis of the writings were done by set of questions in commanding the "Laboratory notebooks", i.e. the set of questions designed to analyzed data, on the issue of completion of the activity, and the issue of data analysis of the rationale and conclusion. The results of the analysis of the writings of graduation student groups showed a qualitative appearance in the greater diversity of epistemic practices on responses to questions concerning data regarding the issues of completion and justification. For answers to questions about the data, we detected the appearance of epistemic operations of our list in the methodology: make predictions, conclusion, definition, description, explanation, by given opinion, using data for theoretical assessment, and evaluating the consistency of the data *(Figure 1*).

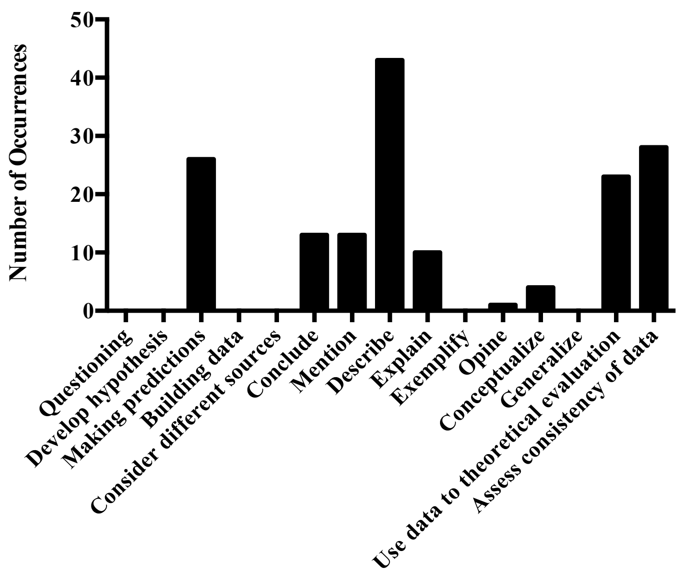

Figure 1 – Analysis of epistemic practices in the writings of the undergraduates groups. Writings were analyzed and classified into the categories of epistemic practices. Here is the evaluation of *data* analysis.

In particular, we draw attention to the greatest appearance of epistemic operating description on these issues compared to other categories. The question of the conclusion of the activity was greater appearance of epistemic operations -conclude, describe opinions, and definition - compared to other categories *(Figure 2)*. For this issue we draw attention to the appearance of the most practical conclusion. However, for that matter this phenomenon was expected, since the heads of the question called for a conclusion to the activity.

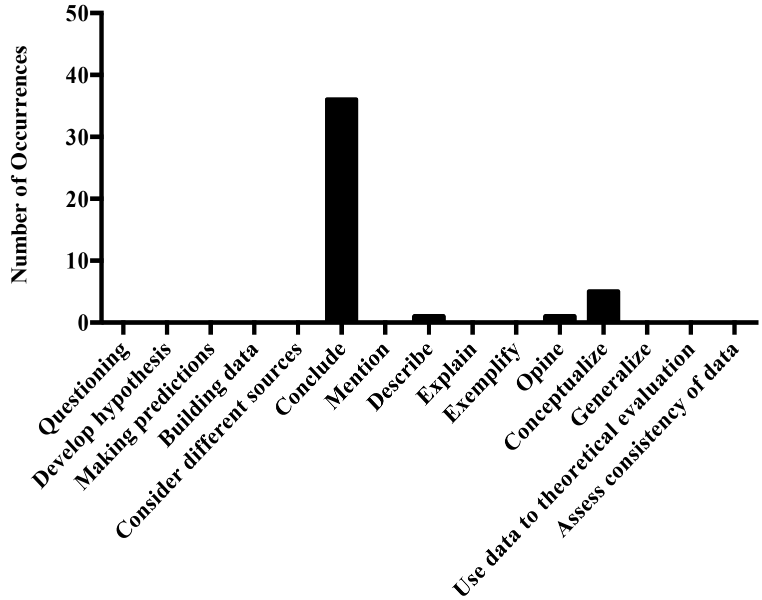

Figure 2 – Analysis of epistemic practices in the writings of the undergraduates groups. Writings were analyzed and classified into the categories of epistemic practices. Here is the analysis of the *conclusion issue*.

In the analyses of the issue of the conclusion justification, we have found the categories of: completion, description, definition and use of data for the theoretical assessment, and evaluation the consistency of the data *(Figure 3)*. We note that for this issue, there was a qualitative difference in the appearance of an epistemic category over another.

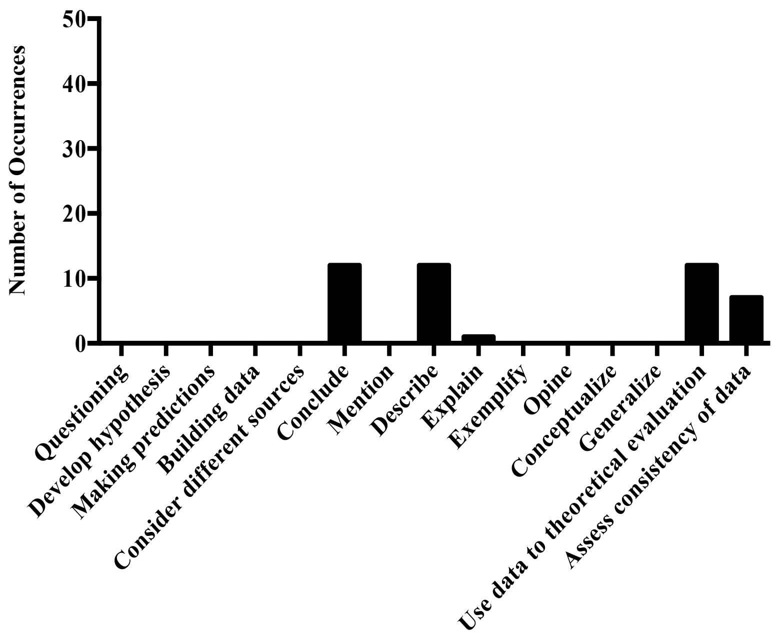

Figure 3 – Analysis of epistemic practices in the writings of the undergraduates groups. Writings were analyzed and classified into the categories of epistemic practices. Here is the analysis of the *justification*.

By the results of the writings of graduate student groups analyzed, data showed a smaller qualitative diversity of the appearance of epistemic operations when compared to those obtained from graduate students.

For answers to questions about data there was a higher prevalence of appearance of epistemic operations: conclude, describe, and use of data for the theoretical assessment and evaluation of the consistency of the data. By contrast, among the categories of epistemic practice that were computed, there is a significant qualitative predominance of the category description in the writings of the student groups *(Figure 4).*

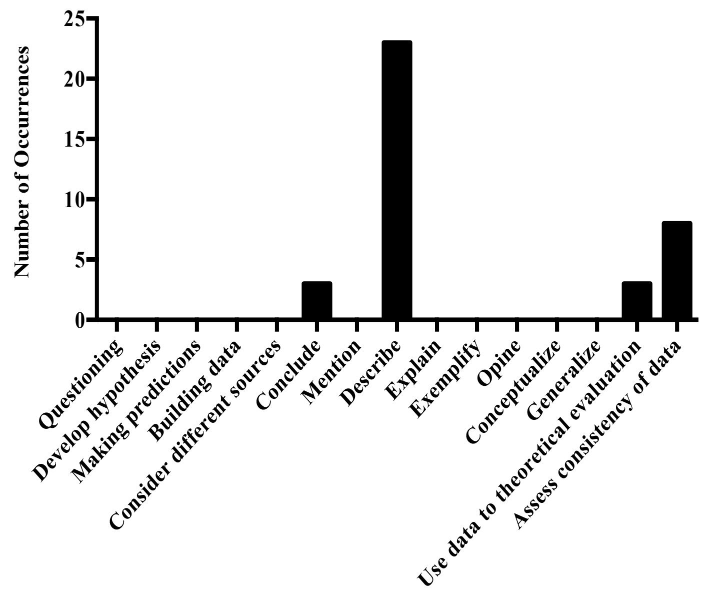

Figure 4 – Analysis of epistemic practices in the writings of the graduated student groups. Writings were analyzed and classified into the categories of epistemic practices. Here is the evaluation of *data* analysis.

For the sake of completion were computed the prevalence of appearance in larger amount of conclusions and appearance to describe, operate and set analyses of data *(Figure 5).*

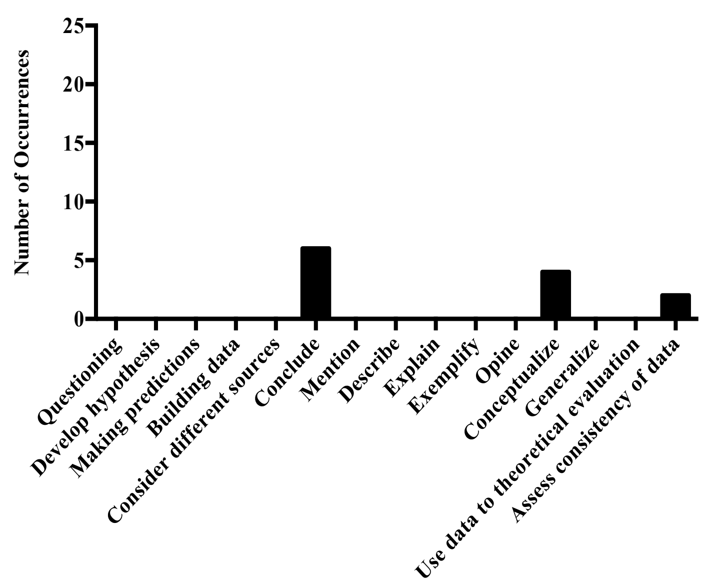

Figure 5 – Analysis of epistemic practices in the writings of the graduated student groups. Writings were analyzed and classified into the categories of epistemic practices. Here is the analysis of the *conclusion issue*.

Regarding the question for justification of analysis, we observed the categories of: conclusion, description and definition *(Figure 6)*. Similarly to the responses of undergraduate students of the groups for that matter, it did not notice that to this question, there was a qualitative difference in the appearance of an epistemic category over another.

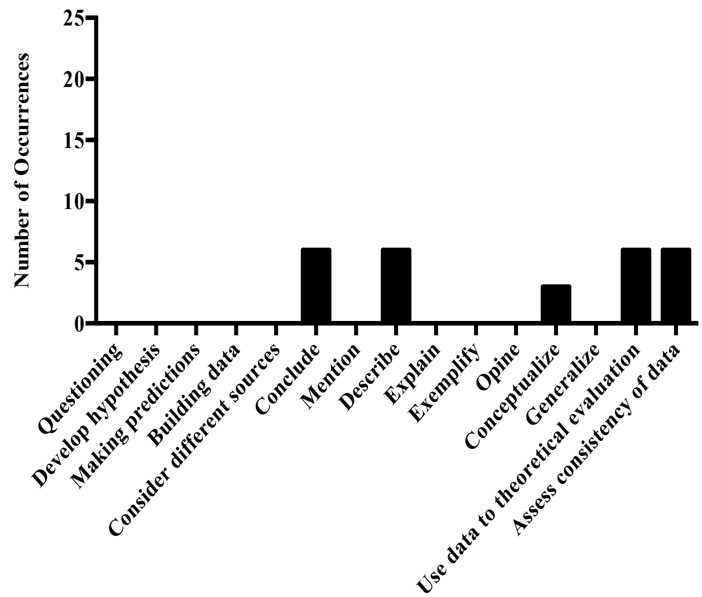

Figure 6 – Analysis of epistemic practices in the writings of the graduated student groups. Writings were analyzed and classified into the categories of epistemic practices. Here is the analysis of the *justification*.

The analysis of the resulting discussions writings by student groups in carrying out the investigative activity has revealed the diverse appearance of the categories for the epistemic practices identified by our theoretical framework, especially when qualitative comparison between the responses of graduation groups and graduate was done. However, for both undergraduate and graduate groups, it is interesting to note that the analysis of the full set of data for the three types of issues, revealed the similarity in the repetition of some phenomena at the structural level of the responses as whole categories of epistemic practices.

For structural issue, it was possible to see the appearance of movement of epistemic categories in three issues following the order of the data, rationale and conclusion the observation of this movement corroborates of what is expected by Toulmin regarding the structure of the argument and as based for us in building activity; for example, we perceive a predominance of larger description for the data analysis issues, according to the appearance of definitions, and a list of descriptions based in theoretical justification, and later predominance of the category conclusion on the question in the formulation was requested a conclusive proposition. Thus, these data suggest the commanding given for each run of each issue in investigative activity stimulate the mobilization of specific categories of epistemic practices, and the need for carrying out certain part of the argumentative structure.

Table 2. Model analysis of epistemic practices in the answers given by the students in the "laboratory notebook" for the analysis of issues of Data (questions 1 to 4).

Epistemic practice	Group of students	Question number	Example excerpt analyzed
Making predictions	7	1	(*) “Using the average of the samples of the actin gene expression and expression of RAG gene, we found that there is high expression of RAG gene, which may mean that the cell is still in differentiating B lymphocytes and accurate expression of this gene” (*) “With the presence of the antigen was a proliferation indicating a possible

	11	3	response to the antigen”
Conclude	4 2	1 4	(*) “Sample cells that our group analyzed are the undifferentiated stage (stem cells)” (**) “After analyzing the data of the northern blot, we conclude that our sample contains cells in pre-B phase”
Mention	9 10	3 4	(*) “According to the explanatory text before point, the fluorescence intensity increases in cells that have larger numbers of IgM and IgD on the surface (...)” (*) “The blot technique N. described in auxiliary text, reports that there were recombining the low molecular weight bands appear (...)”
Describe	1 2	2 4	(*) “(...) It is observed in the graphs the low expression of IgM and IgD, this is due to a low fluorescence intensity at a low cell number” (**) “(...) the board result of W. Blot experiment are unnoticed low molecular weight bands are noted but the high molecular weight”
Explain	8	4	(*) “(...) the result shown in RNA plates of light and heavy chain, is related to an undifferentiated cell, for not having been able to see any gene segment of mRNA over the gel plate”
Opine	11 7	1 1	(*) “We decided that the samples of the RAG gene are larger than the actin gene” (*) “We believe that the cells do not increase in number because they are undifferentiated”
Conceptualize	12 12	1 1	(*) “(...) it is a stem cell since these cells do not present characteristics of any other cell already differentiated” (*) “Pre-B cells are on the way for differentiation. They are between stem cells and fully differentiated cell”
Use data to theoretical evaluation	4 3	4 4	(*) “It is known that the characteristic of mature B lymphocyte requires the presence of IgM and IgD on the surface of the cell” (**) “(...) gene V, D and J are characteristics of B lymphocytes”
Assess consistency of data	5 3	3 1	(*) “(...) due to the high fluorescence intensity results in cytometric there is much expression of IgM and IgD, however, the cells are already at the end of the differentiation process” (**) “(...) can be observed compared there was no significant increase in expression values between the control sample and the test sample”

* *Represents a example of answer insert given by undergraduate students*
** *Represents a example of answer insert given by graduate students*

Table 3. Model analysis of epistemic practices in the answers given by the students in the "laboratory notebook" for the analysis of issues of Conclusions (question 5).

Epistemic practice	**Group of students**	**Question number**	**Example excerpt analyzed**
Conclude	7 1	5 5	(*) “From all samples, we conclude that the sample cell is in pre-B phase” (**) “According to our sample data we characterize a mature B lymphocyte”
Describe	9 11	5 5	(*) “(...) PCR has positive sample for RAG, cytometry presents positive samples stimulation with antigen” (*) “In none of the PCR samples showed an increase in expression of RAG gene for characterizing a mature cell”
Opine	9	5	(*) “We think the cells are differentiated B lymphocytes”

	8	5	(*) "Probably the differentiation stage is pre-B cell"
Conceptualize	12	5	(*) "It is already fully differentiated because it is a B lymphocyte"
	5	5	(**) "(...) Differentiated cells in the bone marrow lymphocytes are B"

** Represents a example of answer insert given by undergraduate students*
*** Represents a example of answer insert given by graduate students*

Table 4. Model analysis of epistemic practices in the answers given by the students in the "laboratory notebook" for the analysis of issues of Justification (question 6).

Epistemic practice	Group of students	Question number	Example excerpt analyzed
Conclude	9	6	(*) "(...) After analysis of the data can then conclude that the cell is a mature B lymphocyte"
	4	6	(**) "(...) Noting from the mRNA of the heavy and light chains, there was no expression of base pairs, then the cell is still under development, so it is a pre-B"
Describe	2	6	(*) "(...) PCR sample increases compared actin samples (...) there was an increase in cell number in the sample at antigen (...)"
	1	6	(**) "Samples with Northern blot showed no bands with low molecular weight, gene rearrangement characteristics for mature B lymphocyte"
Explain	3	6	(*) "From our knowledge and analysis of the data we can eliminate the possibility of B lymphocytes by flow cytometry. However, the PCR data (...)"
	9	6	(*) "Initially, we note that the cell was not a pre-B it is little difference between the expression of RAG gene and actin"
Use data to theoretical evaluation	4	6	(*) "(...) no immunoglobulins in B lymphocyte surface to make that recognition antigen antibody"
	1	6	(**) "Only a mature B lymphocytes have receptors for antigens required for its action in the adaptive immune system"
Assess consistency of data	8	6	(*) "This is a B cell, since it only produces IgM in the experiment flow cytometry (...)"
	4	6	(**) "(...) after exposure to antigen there was no change in cell count by flow cytometry, which also indicates no surface immunoglobulin on B lymphocytes"

** Represents a example of answer insert given by undergraduate students*
*** Represents a example of answer insert given by graduate students.*

DISCUSSION

Immunology is a discipline of biology, which unlike other areas that are focused on description and classification of living things, its constitution and form of knowledge production is based on phenomena description pillars and biological mechanisms, and also guided by scientific research predominantly in the trial. However, the teaching of this discipline is still poorly structured beyond lessons incorporated in rhetoric findings in textbooks. The area of research in science education has been pointing with the results of recent research in the area, proposals for teaching methods that can allow contact of students with the production of culture of scientific knowledge in the fields of natural sciences, such as biology for example. Here, we present the construction of an investigative nature of activity that showed the possibility of mobilization of important categories of practices of scientific culture, such as: capacity description of analyzed data; conclusion based on the relationships of the collected data; and justification of the results analyzed with direct relation in the knowledge base established in the literature, by groups of undergraduate and graduate students. Thus, we consider the investigative activity developed as an important educational tool for higher education to provide undergraduate student flexion and higher education teacher with the scientific culture in the development of knowledge and the theoretical basis of immunology discipline.

In general, the process of research in science aims to build propositions describing a certain reality in which the researcher questions previously the world does. This investigative process is permeated by specific procedures of scientific culture that culminate in the realization of the investigation completion. Bringing the proposal for the teaching of a scientific discipline, research authors in science education advocate and propose the teaching of research in science (Guisasola, Furió, & Cerebio, 2006; Guisasola *et al*., 2007; Smithenry, 2010; Scarpa & Silva, 2013), which can take on different structures with pillars in the degrees of freedom of the students in the development of research - with the proposal of the issue, methodology and procedures forwarded between students and teachers (adapted by Blanchard *et al.*, 2012. However, the consensus among authors is that this teaching by research enables the exposure of students to the production, evaluation and communication (Jiménez-Aleixandre *et al.*, 2008) of the data or findings worked in investigative practice as bases for scientific literacy. This approach procedure of scientific culture by research can be extended beyond the scientific literacy, it means for the teaching of science in basic education (primary and secondary), but playing higher education as a scientific education to the professional level in the university area; this space is a "border" between the construction of knowledge and the training of researchers and/or teachers for the various levels of education.

In our study, we observed that both undergraduate and postgraduate students group correctly concluded the investigative proposed activity, by reaching the correct answer to the set of experimental data that the groups were intended to solve the problem situation, prays stem cell, prays cells in the pre-B stage or prays to the fully differentiated B cell. Thus, which was the "path" covered by the students of the groups for the implementation of investigative activity? To pursue the path of this construction of the conclusions of activity by groups of students, we take the propose formulated by Jimenez-Aleixandre *et al*. (2008), Kelly (2008) and Sandoval (2000) who developed categories to search the epistemic practices in the classroom, and which are classified into three major keys inspired by scientific research procedure: 1) the data production; 2) data evaluation; and 3) the communication of the data collected.

The *production* and *data analysis* is a procedure that involves the mobilization of technical knowledge laboratory, interpretation of data obtained in the experiment and transformation of this information into a language of literary inscriptions, which can then be discussed by the community. For this step, our results obtained from building the structure of investigative activity, showed that stimulation of the contact of the students in immunology discipline with teachers, and researchers in training in post graduation, in an activity with self-teaching structure for research (adapted by Blanchard *et al*., 2012) having: i) a problem and a research question; ii) analysis and discussion of data from experiments derived from everyday techniques of an immunology laboratory; iii) mobilization of typical epistemic practices of investigative activity; and iii) the construction of propositions and conclusions in response to research questioning. The results of the investigative activity construction phase can be correlated to the findings of epistemic practices mobilized by groups of students from both classes, in response to the activity description of the data. At this stage there was a higher prevalence of the appearance of the epistemic practices of description and definition, thus suggesting that student groups make use of this common epistemic practice frequently performed by scientists in objective account of the data found and expressed through numeric values derived from experiments.

The *assessment of the stage of scientific knowledge*, derived from the production data, has important features in the construction of knowledge as opposed ideas, discussion and evaluation of data consistency. This assessment is richer when done collectively in sharing information among peers in the scientific community. So, in that evaluation of scientific knowledge, we take the construction of knowledge by students through oral interactions, i.e., the dialogues among the students during activity in groups. This set of results showed both the undergraduate students as graduate ones, the emergence of common epistemic operations to solve qualitative data (the experiments using flow cytometry and northern blot tools) and quantitative (quantifying the number of cells exposed or not exposed to specific antigens by flow cytometry and analysis of RAG gene expression by PCR). In the resolution of matters that are qualitative data was the prevalence of epistemic operation involving cognitive processes related to verbal language, such as descriptions, definitions and comparisons. About these practices, it is worth remembering that are of great importance in the work done in the laboratory as regards the taking of data, observation and analysis of experiments, description of objects and bodies, and others. Often the rescue of such procedures is made on the basis of the explanations made by scientists about the phenomenon studied by setting the call object's characteristics studied an important element of scientific culture. However, the resolution data involving the solution and formulation of literary inscriptions of numerical order, as production graphics, numerical analysis, it was noted appearance and concentration of epistemic operations in the statements of the students to the epistemic operations linked to logical language, for example, running calculations. Mobilizing this epistemic operation is used by scientists in the construction of literary inscriptions as graphs and tables. Interestingly, these findings can be correlated with the data found the number of appearances of epistemic practices in the description and justification of the experimental data analyzed by student groups. In these two steps, there is predominance in both groups of mobilization of epistemic practices of description, definition, and consistency of data. The analysis of the consistency of the data and comparison of the same with literature also becomes important in the context of production of science. Are scientists committed to the knowledge, principles, laws and generalizations regarding its production area? It is through consistency the scientist reaches his interlocutors. Thus, this analysis suggests the mobilization of important features of scientific culture in data analysis and construction of meanings from them.

The *communication* of data is an important practice in science. It is through communication that the scientist exposes their findings in the scientific community discussion and in society in general. And it's through writing, linked to scientific articles published, the investigator realizes his thinking developed by a certain time, discussed with peers, obtained through experimentation or experience or the fruit of their reflections. Thus, this embodiment of the researchers thinking is supported by a logical structure of language, argumentation. For Toulmin (2006) the structure of a basic argument can be divided into data, rationale and conclusion. In science, the conclusion of an argument is important because it is what's brought the "new" knowledge, as propositions, arising from the data analysis, and supported by theoretical basis of justification. Kelly and Takao (2002) proposed that the logic of the achievement of thought resulting from an investigative process, can be categorized according to the "epistemic status" of the proposals formulated by the students obeying characteristics of movements performed by scientists, for example, identify the given literary description, describe and articulate this data with the theoretical basis for the formulation of a written proposition. In this aspect, our data suggest that the structure of commanding the questions that were answered by students in investigative activity based on argumentative structure proposed by Toulmin (2006), divided into analysis, justification of data and conclusion of the investigation, provided the building propositions written on reports by groups of students, predominantly epistemic status to identify and describe the results, and to cite and articulate results related to the theoretical basis. These data show that the construction of the propositions written in the students' reports is related with propositions formulation basis and fundamentals of scientific language.

The conclusions of this study point out:

• The investigative activity promoted the mobilization of important features of scientific culture, t those related to scientific writing, such as the mobilization of skills for description the findings of the analysis of data with specific knowledge of the study area, and its conclusion; and the formulation of proposals in scientific language;

• It has enabled the development of an investigative activity for further theoretical and empirical analyzes of methodological practices in the field of teaching science, especially in class disciplines of biomedical sciences, for higher education;

• In particular, the application and analysis of data with the graduate class made possible the contact of future (or already existing) university professors in the area of biomedical sciences with teaching for research;

• The development of an activity research for the immunology classes, addressing a complex subject, which can be inserted and applied on the menu of any immunology discipline, because, features format and duration that include hourly loads of immunology disciplines of several courses in the areas of biological and medical sciences.

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