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The nature of science dimension in the teaching discourse. a case study

Summary

Spoken language is the vehicle through which a great deal of teaching takes place, as well as the way in which students show the teacher a great deal of what they have learned. In this context, teaching is mostly a means of providing access to those specific ways of speaking. In particular, metadiscourse is a discursive resource used in discursive exchanges in science classrooms. Despite its importance, metadiscourse has been poorly studied in the science classrooms. One of the metadiscourse methods studied in classrooms is the one corresponding to epistemic markers. The purpose of this study is to analyze how a future Chemistry teacher uses metadiscourse to build scientific knowledge along with the students. A qualitative study of the future teacher's speech was undertaken from discursive exchanges in a physical chemistry classroom. All classes were video and audio recorded for analysis purposes. From total of four classes, a number of extracts were selected from the third class. Based upon a content analysis, representative categories of epistemic markers in the teacher's verbal discourse were inferred. Discourse markers referred to the scientific law recognition as well as its structure and physicochemical properties thay either vary or remain constant during the phenomenon occurence were found. These markers show the importance of considering an explicit work with the epistemic dimension of the content in order to promote the construction of scientific explanations understanding in the science classroom. Additionally, this importance implies the relevance of engaging the future teachers in reflective practices that demonstrate the work with the nature of science from the discursive use of epistemological markers.

Keywords: teacher discourse, teacher training, discursive strategies, science teaching

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Introduction

There is an important relationship between the way in which science is taught and the way it is conceptualized. The curricular proposal, the learning objectives, the teaching strategies and the evaluation procedures used in the classroom carry assumptions about what science is and how scientific activity is carried out.[1] Because of this, students' understanding of the Nature of Science (NoS) is strongly influenced by their own curricular experiences.[2] For the purposes of this paper, we assume the conceptualization offered by Clough[3] indicating the acronym NoS used to refer to questions such as: a) what is and what is not science?, b) how do we work in science?, c) which are the ontological and epistemological foundations of science? and d) how do science, technology and society interact? The construction of an accurate image of science and how it works is strongly related to the image of the NoS that, either explicitly or implicitly, teachers project in their classrooms and how experts conceptualize scientific activity.

In this paper we present the progress of a broader investigation focused on the analysis of future Physics and Chemistry teachers' discourse in school science classrooms. Particularly in this case we are interested in recovering discursive interventions through which a future Chemistry teacher conveys different aspects related to the NoS when working with a group of students on gas transformations, using gas laws in a physical chemistry classroom. To do this, we use textual markers. One of the reasons why the metadiscourse analysis is so interesting and relevant lays on the fact that is shows how intrincately structured language is and how alert to details one should be in the study of language and its effects. Although different frameworks for metadiscourse analysis have been proposed and developed,[4,5] researchs were not contextualized in the discursive exchanges in science classrooms.[6] In this work, we aim to move forward in this scarcely explored context, analyzing the discursive exchanges between a future Chemistry teacher and a group of students, in the process of consultation with the teacher during the scientific explanation construction of everyday phenomenon.

Markers in the teacher's discourse in the science classroom

From the sociocultural perspective, learning is seen as a social process in which language plays a decisive role as a mediating agent of action.[7] Communication is a central element in science classrooms, because spoken language is the vehicle through which much of the teaching is carried out, as well as through which students show the teacher much of what they have learned.[8] Therefore, the classroom is assumed as a social communication scenario, where meaning is constructed in the context of the verbal interaction that takes place between teacher and students.[9] In particular, we are interested in spoken language, as the medium through which much of the teaching takes place and through which students show the teacher what they have learned.[10] In this sense, we consider the discursive strategies used by a future Chemistry teacher in the context of his interactions with students. Discussive strategies are procedures used by teachers to strategically engage in meaningful interaction with students and lead it towards a specific goal.[11]

Among the discursive strategies we are interested in a particular typology, corresponding to those related to metadiscourse.[12] Metadiscourse is the level of discourse that adds another proposition to the propositional theme.[13] Metadiscourse is always present in most conversations and written texts and, in the context of the science classroom, its function is to assist the students to connect, interpret, organize and evaluate school content in the way preferred by the teacher.[4] As such, when teachers discuss science with their

students, they inevitably incorporate a range of metadiscourse (either consciously or unconsciously) to help them manage the complex and lengthy information that is being communicated to them.[14] Although the relevance of metadiscourse has been recovered in different investigations,[14,5,13] how teachers manage the use of metadiscourse in science classrooms has not been sistematically reviewed and analyzed.[11]

In addition to the interactional and content aspects of conversation, Lemke[15] referred to a different type of conversation called 'metadiscourse' or a kind of conversation about conversation. Although it is possible that the considerations made by a science teacher during the verbal interactions with his students about the scientific laws being studied, it may be considered under this category presented by Lemke, it is necessary to consider that such references are a content of the scientific education present in the different curricular proposals of the world and refer to the NoS. Tang[16] in his typology on metadiscourse modalities, identifies the 'epistemology markers' as belonging to the context of evaluative metadiscourse. These markers reflect the teacher's position towards the propositional content status of evidence. Extending the proposal of Tang[16] we consider that this type of markers, frequently used by teachers implicitly in their discourse, express the teacher's vision about scientific activity, a vision that may or may not be in accordance with currently agreed perspectives on science. Epistemology markers indicate the teacher's epistemic position in relation to the status of evidence or proof of the propositional content, in terms of how we know the information being communicated is true. They also include the modalities from which teachers refer to scientists, their work and even allusions to more complex theoretical construction and argumentation works developed by scientists. In this paper we consider how a future Chemistry teacher, during his Practicum, uses epistemic markers that involve a meta-reading on the gas laws, during the consultations carried out by students during the construction of school scientific explanations.

Methodology

The research we develop is classified within a qualitative methodology.[17] Qualitative research in education focuses on the action of teachers and students to understand their reality,[18] either by exploring common sense concepts or through case studies, or by using and selecting instruments such as observation, interview, document analysis, survey, among others.[19] The approach used in this research corresponds to an instrumental case study[20] focused on the description of how the speech of future Chemistry teachers takes shape in the classroom situations in which they intervene. The case refers to the discursive interventions developed by a future Chemistry teacher during his verbal interactions with the group of students while they elaborate school scientific explanations of everyday phenomena. Every class was observed, audio and video were recorded and field notes were registered. The classes were fully transcribed. The transcripts were segmented into episodes considering the changes in the students and teacher's activities.[15] The future teacher developed his interventions in a total of four classes focused on the topic "transformation process of the gaseous state" belonging to the content hub "States of matter", located in the thematic axis "The corpuscular nature of matter" belonging to the curricular proposal for the school subject "Physical Chemistry", corresponding to the second year of Secondary Education, Buenos Aires, Argentina. The first two classes of the learning unit were dedicated to the presentation and work on the contents at the levels of representation of matter.[21] In the third class, the students solved an activity guide and during the fourth and last class the students solved a written evaluation.

The content analysis methodology technique was used.[27] The transcript of the class constituted the main corpus analyzed and an initial approach to its contents was made through a fluctuating reading. After this initial stage, the material was explored. At this point, coding operations were performed, considering the snippets of text as registration units, the defininion of numbering rules and the classification and aggregation of information into symbolic or thematic categories. At this stage, it was carried out the trimming – definition of the thematic analysis units –, aggregation – units to be grouped into different categories – and enumeration – co-occurrence and frequency analysis.[22] In this work, we are interested in the analysis of the practitioner's interventions during one particular episode that takes place in the third class, during which the practitioner collaborates with the students in the resolution of the activities focused on providing explanations of everyday phenomena involving gaseous transformations. A content analysis[23] was developed, identifying, from an inductive analysis, discursive interventions called "signs" and that correspond to discursive strategies that express epistemological discursive markers.

Results

Next, we present the analysis of one of the two episodes into which the third class of this didactic unit was divided. The first episode was signed up at the beginning of the class. In the second episode, the students solved an activity guide about "gases" and the practitioner answered all the students queries. Thereafter, we stop at the analysis of this last episode corresponding to the second class of the didactic unit. For the work with gas laws, the practitioner offers clues intended to recognize the law in situations where it applies; clues intended to identify structural features of the laws worked and hints intended to recognize the properties that change or remain constant. In the context of the proposed classification, a first group of clues refer to the recognition of shared features present in the structure of the laws worked; in particular, that the generalizations worked out imply a set of three properties of gases, two of which are variables functionally related to each other while the third of them remains constant ("*One holds one thing constant, another, another, and the other, another* ", line 15; "*Whenever two things change, there is something that does not change*", line 30; "[….] *there are three laws and you have to see what changes in one and what changes in another*", line 30). In some interventions, the practitioner is explicit regarding this set of properties -pressure, temperature and volume- which vary while the rest remains constant. The use of the plural form when referring to the properties that change and the use of the singular form in the remaining case are usual indicators in the practitioner's interventions ("*Well, first of all, the important thing is always to find out what law is involved. In order to know what law it is, we have to see which variables change and which one stays constant.*"; line 78).

The indications made by the practitioner in the context of this class indistinctly alternate between the recommendation to identify which property does not change ("*First you have to identify what does not change*"; line 48; "[….] *in a pressure cooker, what remains constant?*", line 48); on focusing attention on recognizing the properties that vary ("*First, first identify which variables change*", line 257; "[…] You always have to see first which variables change"; line 323, class 2) or, indistinctly, identifying both the properties that change and the one that does not ("*That is why it is important that you see what they are… what changes and what does not change. Always keep that in mind*", line 54; "*The question of those three is to realize what changes and what doesn't*", line 245). This type of sign, in any of its modalities, does not allow us to identify what law is involved; it provides clues

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regarding the common structure of the set of laws worked. Along with the rest of the clues, it operates at an epistemic level of the teacher discourse.

A second group of indications or clues is aimed at facilitating the identification of the law that allows, for example, modeling a specific situation ("*What law is this* [….]? *Well, the volume and temperature change here. Done, it's Charles. That's the first thing you have to do*"; line 27). This identification requires both prior recognition of the properties of the gas in the situation under study and recognition of those properties that are also variable in the event. The student would be able to recognize the law, for the situation of implementation, by identifying the three properties of the gas, which property does not change, and also recognizing that the remaining two will be those functionally linked by the law. This line of reasoning assumes an implicit one: that the worked laws connect two variables, corresponding to a set of three thermodynamic properties of the gas, the rest remaining constant. This implicit is proposed by the practitioner, at times, as a sign during the explanation and, therefore, it is made explicit. In a passage from this episode, the practitioner explains to a group of students how to recognize that the volume does not change in a given situation. Once recognized, he continues: "*There you almost already found the law. That is why it is important that you see what they are... what changes and what does not change. Always keep that in mind. Okay, you already found that the volume does not change. What changes? The temperature and the pressure*" (line 54). In this passage he uses both levels of clues, explicitly. In contrast, in other interventions, the sign corresponding to the epistemic level remains unexplained. In the above passage (line 54), it is interesting to observe that the practitioner's emphasis placed upon the identification of the changing property during the transformation neglects the change identification in the remaining properties.

This modality in which the practitioner uses this sign, reduces the event analysis to one of the properties, inferring the variation of the rest as a result of applying the mentioned rule. Thus, the law can be identified if the property unchanged is recognized, because of its application, also assuming that the two remaining thermodynamic properties will be those functionally linked by the law. The application of this rule proposed by the practitioner makes the identification of the law easier, at the expense of decreasing the analysis of the situation. Another type of sign is used by the practitioner to facilitate the student both the recognition of the properties that change and those that do not change. The application of the laws to explain everyday events allows the practitioner to select parts of the event statement referring to properties of objects known by the student which can be used to identify variables and parameters. In this third class, during the communication exchange with a student, the practitioner tries to direct her to the recognition of the property that, for the event stated in the activity ("*If there is no safety valve in a pressure cooking pot allowing the steam to come out, it can explode when cooking*") including an analogy into a question ("*If I have a pot, can the pot stretch like a balloon, getting bigger or smaller?*"; line 54).

Through this question, the analogy proposes the pot-balloon comparison, regarding a property such as the possibility of deformation. By including the comparison into a question, the practitioner leaves open the possibility of differentiating the behavior of objects against the expansion of the contained gas. The usage of an analogue assumes that certain features are transferable from it to the topic. In this case, what matters is the difference regarding a feature, and not its similarity. In this sense, the question facilitates the emphasis on the uneven behavior. In this case, the practitioner answers the question -without waiting for the student's response- and continues with another sign to recognize the volume as that property of the gas mixture that does not change in this event ("*In a pot the volume is always the same: when they tell you 'rigid container', 'pot', something hard, the volume cannot change*"; line 54). This last type of sign supposes a rule obtained from the generalization from the particular situation presented in the activity. The practitioner resorted, in this case, to a comparison in order to identify the constant property of the gas (or mixture of gases) in the particular situation. The clue, in this context, is a certain property of the material of the container holding the mixture of gases. Therefore, as long as this property is present in the container holding the gas (or mixture of gases), the volume, during its transformation, will remain constant.

Therefore, we can say that the epistemic markers represented by the first and third clues would make the recognition of the law easier in a given situation. The following intervention by the practitioner exemplifies this last relationship: "*Well, first, first the important thing is always to find out what law is. To see what law is, we have to see which variables change and which one stays constant. In a hard pot, what will not change?*" (line 78). During it, the practitioner offers clues to the student in a two-way interaction: explaining the structure of the laws worked on, a shared structure regardless the related variables ([...] *"the important thing is always to find what law it is. To see what law is, we have to see which variables change and which one stays constant*") in addition, offering clues to recognize the property that remains constant ("[...] *In a hard pot, what will not change?*"). This double set of signs constitutes the practitioner's discursive strategy to facilitate the recognition, by the student, of the law that allows modeling the problem situation. In Figure 1 we present the epistemic markers recognized in the future teacher's speech.

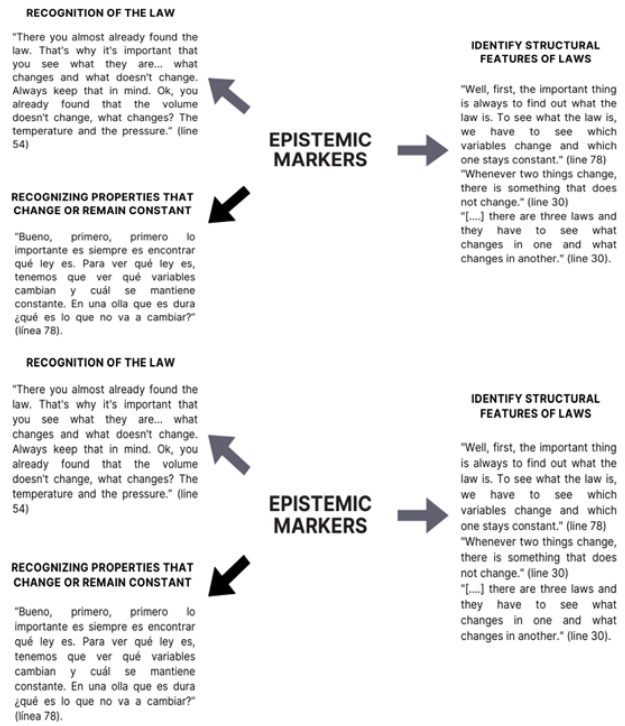

Figure 1 Epistemic markers recognized in the future teacher's speech.

Source: self made.

Discussion

The analysis of the class, focused on the resolution of activities by the students and their queries to the practitioner allowed us to explore

teaching discursive strategies that, in the context of the remaining classes of the teaching approach -focused on the practitioner's presentation- were presented quantitatively less relevant. These strategies consisted of more or less explicit signs offered by the practitioner to the students for the activities resolution. These signs exemplify usage instances of a metadiscourse by the future teacher, through the use of epistemic markers. Despite the current importance that the understanding and construction of scientific explanations has in science teaching, didactic research has evidenced difficulties in teaching practices to be promoted in the classrooms (RODRIGUES and PEREIRA DE PEREIRA, 2018; SANDOVAL and REISER, 2004; TALANQUER, 2007). Among these difficulties, for example, it is pointed out that teachers privilege teaching practices that involve students in instances of construction of scientific explanations that do not promote contexts of dialogic exchanges (BRAATEN and WINDSCHITL, 2011). Consequently, teaching practices, instead of actively involving students in the construction of school scientific explanations of everyday phenomena, are reduced to the reproduction of explanations provided by textbooks or teachers. The epistemic markers recognition allows to address the didactic work of the explanations from an epistemic dimension starting from the recognition of quantities that may change or remain constant, and the recognition of the chemical law involved to understand the phenomenon. The practitioner developed these markers without previous reflection about their educational use. These markers emerged from an intuitive work. We agree with Viennot (2020) that this demands a reflection about the teaching work with explanations. To go beyond this working modality during teaching and to move towards an explicit work that enables students to incorporate metareading associated with these markers constitutes a challenge facing the teacher training.

Conclusion

In this work the discursive markers used by the future teacher were contextualized in inquiries made by students during the construction of school scientific explanations. The discursive exchange context where the study was performed may have enabled the emergence of categories –epistemic markers- specific to that context itself. Therefor, it would be relevant to investigate the didactic work performed with these markers during instances of exchange between teachers and the whole study group. Eventually, Tang[20] submitted these markers in a discursive exchange context in the science classroom. The results of this study reinforce, initially at least, its presence in a new exchange context between the teacher and the student group. On the other hand, the discursive use of these type of markers is linked to the teaching work with the Nature of Science, being this aspect particularly relevant regarding their teaching implications, given the importance that this epistemic dimension holds in various curricular proposals.[24] In this sense, to explicit the teaching work with these categories would enable the future teachers to recognize the way in which they mediate the work with the Nature of Science through their speech.

The modalities found for the epistemic markers are not intended to be exhaustive beyond the boundaries of this research. However, the analysis developed should serve as an appropriate framework to be expanded from other researchs in other settings. In a teaching environment where students are encouraged to participate in the process of construction of explanations, teaching practices should consider, for example, the recognition of laws and variables involved in the process to be explained. In this sense, the use of epistemic markers becomes a generalized discursive practice implicitly developed by teachers, together with the use of discursive strategies linked to metalanguage.[6] In teacher training, making these teaching practices explicit from a reflective standpoint[25] is challenging, especially in pre-professional training. In this context, reflective practice is installed as a fundamental training requirement and the analysis of discursive mediations constitutes a dimension that could help improve teaching practices. From this belief, in this work, priority was given to the didactic work with epistemic markers.[26–31]

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Conflicts of interest

The autor declares there is no conflcit of interest.

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