Science Teaching in Primary School and the Importance of Interdisciplinarity in Knowledge Construction. Case Study: "Do Snails Prefer Cabbage or Lettuce?"

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Abstract. The way in which, traditionally, sciences have been taught in primary school has not allowed for the integrated use and development of the knowledge and skills acquired in the different curriculum areas. Therefore, it is necessary to promote a science teaching and learning process that encourages and enables the use of that knowledge in the context of different situations that are meaningful and relevant for children. With this goal in mind, this article seeks to illustrate, through the analysis of the process of exploration of the activity "Do snails prefer cabbage or lettuce?", which was conducted with a class of the 4th year of primary school, that research-based science activities enhance the integrated and meaningful use and development of knowledge and skills from other curricular areas, especially language and mathematics.

Keywords. Inquiry activity, Integrated and interdisciplinary approach, Science Education.

1. Introduction

The lack of time to complete curricular programmes has occasionally been employed as a justifying argument for the low level of commitment towards science teaching in our primary schools. Behind this argument lies the idea that there are priority skills, such as reading, writing and calculus, which are subject to assessment tests at the end of each primary school year, which are negatively affected when other curricular areas are addressed in the classroom [1].

From a different perspective, Costa [2] points out that the way practical science activities have been conducted in the classroom indeed constitute a waste of time. He argues that, most of the times, these are used merely as an illustrative resource for what was transmitted by the teacher. In that case, "all of the discipline's potential for the development of transversal and specific skills is lost. This is why teachers say that these activities "waste a lot of time", which is actually true because of the way they are used" [2, p. 34]. Indeed, when these activities are used in this way, the student takes on a passive role, fundamentally limited to the accumulation of knowledge. Learning loses relevance, and its personal and social use becomes ineffective.

Practical and investigative science activities provide a privileged context for the meaningful use and integrated development of the knowledge acquired in those curricular areas [4, 5]. Several authors argue that basic reading, writing and calculus skills are better developed when contextualised into other curricular areas and used as instruments at the service of those areas [1, 4, 6]. The recommendations that resulted from an expert meeting on science teaching in primary school, promoted with the endorsement of UNESCO in 1983, stated that: "Science can positively assist children in other subject areas, especially language and mathematics" [7, p. 7].

The understanding of numbers, orders of magnitude, mediation processes, etc. is considerably developed and reinforced when children apply those mathematical notions to the resolution of problems that emerge from Science activities. Similarly, these activities, when conducted in an environment of freedom of communication and respect for the opinions of others, give rise to situations that stimulate children to talk, communicate and discuss ideas, to describe, interpret, present and discuss the result of observations; they learn and use new, more suitable words to explain and organise their own ideas; elaborate written records, etc. [1, 4, 8]. Children feel a natural impulse for communication when they are engaged in learning experiences that are truly meaningful for them [1].

Children who are usually shy and/or show little interest become quite active and communicative during the development of this kind of activities. From an identical perspective, Worth [8] points out that the students' linguistic skills are clearly developed when practiced within an appealing and significant context. Such a context is offered by the practice of inquiry-based science teaching, which promotes vast opportunities for students to become involved in the significant use of language. We agree with Sanmartí when he states that to, in order to learn Science, it is necessary that children: "(…) enjoy learning how to think, create theories, relate facts with those theories... And learn to talk, read, write, build charts and schemes... In other words, when they learn science, they learn to use language and mathematics" [9, p. 14].

Moreover, science learning must emphasise the establishment of links to other curricular knowledge, in contexts that are meaningful for students. This emphasis is consistent with the philosophical enquiry of the curriculum supported by Fisher: "The philosophical approach can enrich science not only through planning and review stages, but also in bridging science activities to other elements of the curriculum and to the world of everyday experience. Without this bridging or linking to meaningful activity in everyday life science will seem to have limited relevance, and instead of being something that helps children to make sense of their world will simply remain an imposed body of knowledge" [10, p. 200].

2. Objectives

The traditional way in which sciences have been explored with primary school children tend to discourage the integrated use and development of the knowledge and skills acquired in the various curricular areas. Therefore, it is necessary to promote a science teaching and learning process that encourages and enables the use of that knowledge in the context of different situations that are meaningful for the children. To this aim, this article seeks to illustrate, through the analysis of the process of exploration of the activity "Do snails prefer cabbage or lettuce?", that inquiry activities entail the use of, and enhance the integrated development of knowledge and skills from other curricular areas, particularly language and mathematics.

3. Context of the practice and methodological options

In a 4th-year class of a Portuguese primary school, comprised by twenty-five students, 13 boys and 12 girls, aged 8 to 9 years, several inquiry activities were explored by the two primary school teachers who co-author this article. In the classroom, the two teachers collaboratively and simultaneously took the roles of teachers and researchers. One of the activities was aimed at investigating the food preferences of snails, i.e., whether they prefer cabbage or lettuce. This activity was designed by Sá [1] and it aims at developing animal study skills, by means of systematic observation in controlled conditions by the students. According to the author, the snail is an excellent subject for study in the classroom: it is a friendly animal that children like; it is harmless; it is small; its mobility is very limited, so it can be observed slowly and carefully.

The data generated during the process of exploration of the activity in the classroom was collected in the form of field notes, audio recordings, pictures and records kept by the students, e.g., drawings and small written texts. This data was subsequently compiled in the form of class diaries - descriptive and reflective narratives on the most important events that took place in the classroom setting. The class diaries constituted both a data recording method and a strategy for reflection and for the modelling of the teaching-learning process [11]. It is based on the analysis of the diary on the activity "Do snails prefer cabbage or lettuce?" that this article presents the process of teaching and learning promoted in the classroom.

4. Analysis of the classroom diary

Divided into small groups, students identify the basic aspects of the external morphology of the snail and investigate its food preferences - whether it prefers cabbage or lettuce.

A. They communicate what they know about the snail.

The students' initial knowledge focuses mainly on the external characteristics of the snail and on some of its behaviours: "it has a shell"; "it moves very slowly"; "it's sticky"; "it leaves a trail"; "it's got 'tiny horns', which are its eyes"; "its shell is brown and black"; "its shell is

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soft for us if we step on it, but for other animals it's hard, and can serve as protection (Fábio); "when they're scared they get inside it; "only when something hurts it" (Joana G.).

B. The groups observe the snail.

Each group is provided a snail inside a glass jar. Students observe the characteristics pointed out above and discover others, such as the respiratory hole located beneath the shell, and infer on its function: "I saw a hole, it must use it to get into the shell!" (Joana); "the hole is to let air in" (Inês); "it's for breathing"; "it's on the left side (Sofia)."

Figure 1. Observing the snail

C. How does the snail move around?

Students visualise muscle contraction waves occurring on the underside of the snail's foot, as it moves inside a glass jar: "it has no legs" (Patrícia); "it moves in waves" (Gonçalo); "we can see some lines under it" (Sérgio); "the lines are moving". "The lines are on the foot and it looks like they go from one side to the other" (Fábio); "it's sticky and it shrinks and stretches" (Joana); "it leaves a trail when it moves, and when you pick it up, it shrinks into its shell (Inês)".

D. The students make a drawing with captions.

After some discussion, some scientific information is inevitably provided on the functions of some of the snail's external structures. At the end, the students make a drawing with captions containing this information.

E. What does the snail feed on?

The first answers include "grass" or "vegetables". However, when asked about what type of vegetables, they mention "cabbage" (Guilherme) and "lettuce" (Carolina). Among these answers, there were those who raised the fact that the snail it is a "herbivore" (João).

Figure 2. Observing the muscle contraction waves

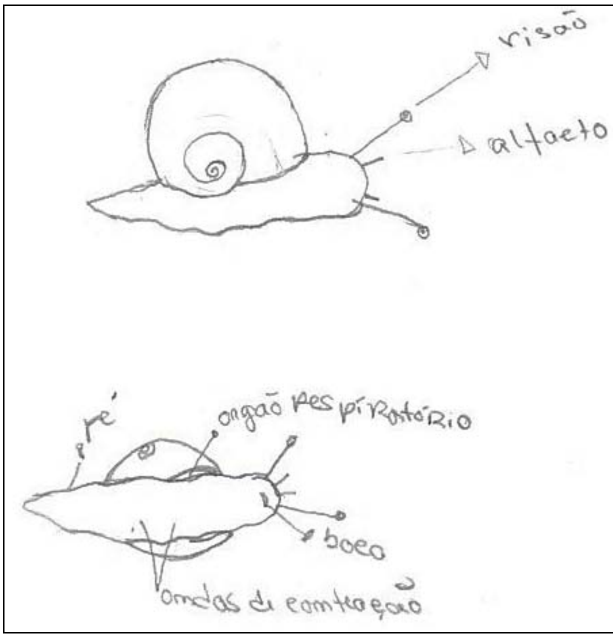


Figure 3. Drawing of the snail with captions

F. They investigate the snail's food preferences.

The groups are now given the following challenge: "Does the snail prefer cabbage or lettuce?" To solve this problem, they discuss a research strategy, among themselves and with the teacher:

- Students make predictions.

The class is asked to make predictions about the snail's favourite food. Most students predict that the snail will prefer cabbage (84%), while a minority says it will prefer lettuce (16%). The predictions are recorded in a table.

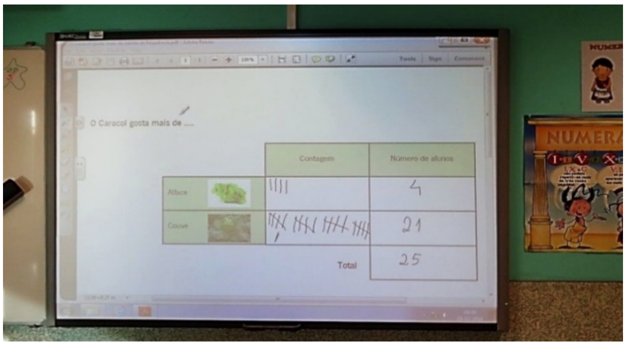


Figure 4. Record of predictions

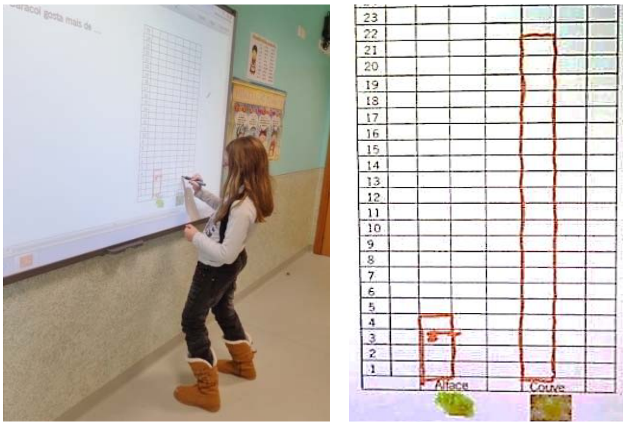


Figure 5. Graphic representation of the predictions

o The children prepare a bar graph.

The students prepare a bar graph with the data from the previous predictions. They count and calculate the difference in the predictions between the vegetable with the highest and lowest frequency - "seventeen" (Inês).

o Each group builds a terrarium.

For the construction of the terrariums, students suggest the following materials: "earth" (João R.), "food" (Bruno) and "a box to put the snails in" (Inês). When asked about the type of "food," students refer "cabbage" and "lettuce", as the goal is to investigate which of these vegetables is preferred by the snail.

o Students measure the initial amount of food to put in the terrarium.

The children answer the question: how will we measure the amounts of lettuce and cabbage eaten? The answer to this question implies that students know of a method of measuring the amount of food, so that, after a few days, they can find out whether the snail prefers cabbage or lettuce. In the absence of ideas from the students, the teacher shows a sheet of squared paper as a way to catalyse the students' thought process and mobilise knowledge previously acquired in other curriculum areas - calculating areas through grids. The idea then arises to outline the leaves of cabbage and lettuce on the square paper in pencil: "we can draw and then count the squares, before and after (Guilherme).

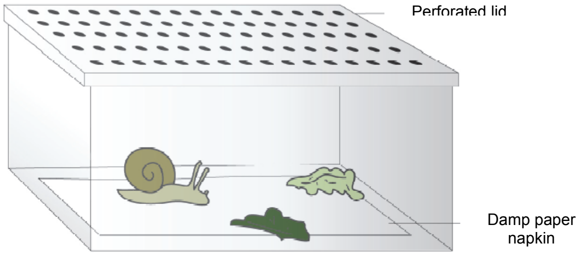


Figure 6. Illustrative example of a terrarium

The amounts of vegetables eaten are given by the difference between the number of initial squares and the number of squares remaining after two days.

o They count and record the initial number of squares.

After outlining the leaves of cabbage and lettuce, the students count the initial number of complete squares. Incomplete squares are obtained by approximation. At the end, the leaves are placed in the terrariums along with the snails. The terrariums are then covered with perforated lids so that the snails cannot escape.

G. After two days, they calculate the amount of food eaten by the snail.

The groups use the same square-based measuring process and record the data in a table. Taking the initial and final number grid cells, each group calculates the amount of lettuce and cabbage eaten by the snail after two days, using the grid as a unit of measure.

Taking the data obtained in all the groups, the students calculate, on the classroom board, the average amount of food ingested by the animal during the two days it spent in the terrarium. They obtained the following average results: lettuce 15.5 squares; cabbage 6.25 squares.

Figure 7. Measurement of the initial leaf area and their placement in the terrarium

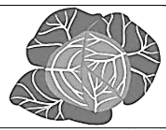
Alimentos	Número de quadrículas no início	Número de quadrículas após a experiência	Número de quadrículas comida
	64	42	22
	70	65	5

Figure 8. Records prepared by the groups (in portuguese)

H. They interpret the data and draw conclusions.

The results obtained are not identical in all groups. In three of the groups, the snail ate more lettuce, whereas in one group, it ate more cabbage. However, because the investigation was carried out in 4 groups of students and, therefore repeated four times, it was possible to conclude, with reasonable credibility, that snails prefer lettuce, as, in the vast majority of cases, throughout the two days, they ate a greater number of squares of lettuce.

I. Illustrated record of the activity

By way of a summary, the students wrote a short, illustrated text on the activity and on their main learnings.

Figure 9 Illustrated text on the activity

With contributions from the various individual texts, the following collective text was prepared:

Snails

"Snails are animals that have tentacles on their head". "At the tips of the longer tentacles, are their eyes". "The bottom tentacles are smaller and they smell through them". "Their shell is hard ... it serves as protection!" We also found that they have a very tiny mouth". "It also has a hole to breathe through". It produces a goo to slide over and makes little waves on the underside of its foot". "Snails are oviparous animals". "Between cabbage and lettuce, the food they prefer is lettuce." This was what we saw in the experiment we conducted in class". "In that experiment, we built a little house for the snail". "What we observed was that it eats both cabbage and lettuce, but prefers lettuce". "We enjoyed this lesson very much".

5. Final considerations

Sciences are an area of knowledge that is, by nature, interdisciplinary, enabling the establishment of relevant links to other fields of knowledge. When properly explored in the classroom, science activities entail the use of, and at the same time, enhance the development of knowledge from other curricular areas, especially language and mathematics.

Currently, there is wide recognition of the importance of language in science learning as a tool for communication and joint construction of scientific meanings [12,13,14,]. In the teaching and learning process previously described, the children, in a context of social interaction, resort to the use of language to: a) communicate and discuss their initial knowledge on the snail with their classmates; b) record, in writing, and orally communicate the details of their observations; c) describe, in their own words, some of the structures identified in the animal's body; d) share their inferences on the functions of some of those structures; e) learn and use new words, such as "tentacles", which they previously referred to as "tiny horns"; f) describe the snail's mode of locomotion and its reactions to certain external stimuli; g) communicate their predictions on the snail's favourite food to the class; h) discuss, with each other and with the teacher, a research strategy to obtain an answer on whether the snail prefers cabbage or lettuce; i) record their predictions; j) organise and record written and pictorial information obtained on the problem being investigated: l) prepare and communicate their findings; m) prepare an illustrated written text of the activity performed in the classroom, based on the individual texts produced.

All this discursive activity is generated in the classroom as a result of a learning process in which children are deeply involved and, therefore, their oral and written communication skills are developed in a more natural way. According to Vygotsky [15], written communication, for example, must be felt by the child as an inner necessity, in the context of meaningful and relevant activities. In this regard, Sá [1] points out that, for many children, writing an essay on the Sun, for example, is a painful and most likely unsuccessful task. But writing a story about a snail that they observed, describing the procedures they used in order to find out whether it prefers lettuce or cabbage, is talking and writing about a very intimate experience, in which there is effectively a personal and intellectual involvement by the children.

During the execution of the research strategy, in order to solve the problem with which they were confronted ("does the snail prefer cabbage or lettuce"?), the children, stimulated by the actions of the teacher, in addition to a whole set of mental processes, also activate and mobilise knowledge from the field of mathematics, namely: a) they organise the data on the predictions made in a two-way table; b) with this data, they build a bar graph; c) they interpret the information contained in the graph and calculate the difference between the vegetables with the highest and lowest prediction frequency; d) they measure the area of pieces of cabbage and lettuce leafs using a square grid; e) they count the total number of squares at the beginning and end of the study; f) they calculate the amounts of food consumed by the snail, taking the difference between the initial and final number of squares; g) they calculate the average amount of food ingested by the animal, using the data obtained by the various groups of students.

Learning sciences in this way promotes the mobilisation and the contextualised development of knowledge acquired in other curricular areas, as, according to Perrenoud [16, p. 32]: ‘Classic school exercises allow for the consolidation of the notion and the algorithms of calculus; it does not work on transference. (…) Frequently, the fundamental notions have been studied in school, but removed from any context. They are, therefore, a "dead letter", like fixed assets with which we cannot make informed investments’.

The mobilisation and use of all these knowledge and skills constitute important resources for the process of building scientific meanings, which, in turn, are particularly well developed when contextualised within concrete situations that have a deep meaning for the students, as can be the case with science activities. Therefore, in order to ensure a genuine understanding of the contents of the various fields of knowledge, these must be meaningful for students. It is sometimes argued that, as students advance in school years, they lose the abilities of writing, reading and calculus. In this regard, Gardner [17] points out that students ‘do not lose those abilities, but rather the opportunity for productive use in meaningful contexts for them’.

Inquiry activities, such as the one described in this article, can favour the development of an integrated pedagogical practice, where the different areas of curricular knowledge become relevant and meaningful for the children. The goal is, therefore, to promote a practice that encourages and enables the mobilisation of these resources and knowledge within concrete, contextualised situations that have a deep meaning for children. However, the mobilisation of knowledge does not occur automatically, it is acquired by the exercise of a reflective practice in situations that allow for the mobilisation, transposition and combination of knowledge [16]. It is that contextualised reflective action in concrete situations that imparts meaning and relevance to curricular knowledge.

6. References

[1] Sá J. Renovar as Práticas no 1º Ciclo Pela Via das Ciências da Natureza. Porto: Porto Editora; 2002.

[2] Costa F. As actividades práticas na educação em ciência: uma oportunidade perdida? In: Hamido, et al., (Orgs.), Transversalidade em educação e em saúde. Porto: Porto Editora; 2006, p. 31-38.

[3] Sá J, Varela P. Das Ciências Experimentais à Literacia: Uma proposta didáctica para o 1º ciclo. Porto: Porto Editora; 2007.

[4] Harlen W. Enseñanza y aprendizaje de las ciencias. Madrid: Ediciones Morata; 2007.

[5] Hammerman E, Musial D. Integrating Science With Mathematics & Literacy. New Visions for Learning and Assessment. Thousand Oaks, California: Corwin Press; 2008.

[6] Dyasi HM. Visions of Inquiry Science. In: R. Douglas R, et al., (Eds.), Linking Science & Literacy in the K-8 Classroom. Arlington: NSTA Press; 2006, p. 3-16.

[7] Harlen W. Science as a key component of the primary curriculum: a rationale with policy implications. Perspectives on education Primary Science, 1, 4-18. London: Wellcome Trust, 2008.

[8] Partridge J. Conducting a science investigation in a primary classroom. Teaching Science 2006; 52 (2); 44-45.

[9] Sanmartí N. Un reto: mejorar la enseñanza de las ciências. In: Catalá, et al., (Eds.). Las ciências en la escuela. Teorías y prácticas. Barcelona: Editorial Gráo; 2002.

[10] Fisher R. Teaching Thinking: Philosophical Enquiry in the Classroom. London: Bloomsbury Publishing Pic; 2013.

[11] Zabalza MA. Diarios de clase: un instrumento de investigación. Madrid: Narcea; 2004.

[12] Rivard LP, Straw SB. The Effect of Talk and Writing on Learning Science: An Exploratory Study. Science Education 2000; 84, p. 566-593.

[13] Català M, Vilà N. Las funciones lingüísticas en el proceso de adquisición de los conocimientos científicos. In M. Catalá, et al., (Eds.). Las ciencias en la escuela. Teorías y prácticas. Barcelona: Editorial Gráo; 2002, p.89-103.

[14] Aleixandre, JM. Comunicación Y lenguaje. In J. Aleixandre (Ed.), Enseñar ciências. Barcelona: Editorial Graó; 2003, p.55-71.

[15] Vygotsky LS. Pensamento e Linguagem. São Paulo: Martins Fontes Editora; 1987.

[16] Perrenoud P. Porquê construir competências a partir da escola? Desenvolvimento da autonomia e luta contra as desigualdades. Porto: Edições ASA; 2001.

[17] Gardner H. La mente no escolarizada. Cómo piensam los niños y cómo deberían enseñar las escuelas. Barcelona: Ediciones Paidós, 1993.