"SUSTAINABLE MANAGEMENT OF RESOURCES": EVALUATION OF PRACTICAL ACTIVITIES IN NATURAL SCIENCES TEXTBOOKS OF THE 8th GRADE ACCORDING TO THE COGNITIVE LEVEL

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Abstract

Practical activities (PA) are a privileged strategy, from the perspective of the current science education, to improve the cognitive, procedural and attitudinal skills and core values, for the increase of scientific literacy, which is essential to “build” more active, informed and responsible citizens in Education for sustainability (ES). Since PA and textbooks are very important in pedagogical practice, evaluation studies on these two aspects of teaching and learning processes have been widely developed in science education research. The focus of this study was the assessment of the PA cognitive level (Bloom’s revised taxonomy) in the Natural Sciences textbooks of the 8th grade, of Portuguese middle school, in the theme “Sustainable management of resources”. The main goals established were: 1) to identify the textbooks with the highest number of high cognitive level PA; and 2) to analyse and compare the distribution of the PA in the 2007 and 2014 textbooks, according to the cognitive level and the publishing house. The sample consists of ten textbooks, five of each edition (2007 and 2014), and from four publishers. The selection of the textbooks was based on data provided by the Ministry of Education and corresponds to the most used in Portuguese schools in 2013/2014 and 2016/2017 school years. The PA considered, besides being the ones proposed throughout the text and at the end of each subtopic/subdomain, are those that have been carried out, more often, in the classes. The procedure involved a content and quantitative analysis. The results revealed an increase in the number of high cognitive level PA in the 2014 textbooks, particularly in the “Evaluate” and “Create” categories. However, any textbook incorporates a higher number of PA of a high cognitive level when compared to the low cognitive level. Regarding the PA typology, the diversity is low with prevalence, in both editions, of pencil and paper. In the 2014 textbooks, compared with those of 2007, there are more proposals for project and investigation. Nevertheless, laboratory and Science, Technology, Society and Environment (STSE) maintain their frequency in both editions and fieldwork are none in the most recent editions. In order to provide students learning with a higher cognitive involvement and being aware of the importance of PA, in general and particularly of the laboratory, STSE and fieldwork, for the students capacities upgrade related with the development of scientific literacy, in the scope of a ES, we recommend that, in future editions, a larger number of high cognitive level and laboratory/STSE/fieldwork PA should be included in the textbooks.

Keywords: Bloom’s taxonomy, cognitive level, Natural Sciences, practical activities, textbooks.

1 INTRODUCTION

In general, practical activities (PA), included in textbooks, are important resources in the teaching and learning processes of science education (SE), particularly in Natural Sciences (NS). The education should meet a contextualised science, able to contribute to a meaningful learning that guarantees the formation of conscious young people committed to build a sustainable society. For this, it is necessary to avoid that students have superficial levels of learning. Consequently, it is important that textbooks include diversified PA, enabling the development of different cognitive skills. One of the strategies could be the planning and the definition of learning goals, according to higher cognitive levels, considering, for example, the Bloom’s taxonomy [1]. This is based on the principle that learning goals require different levels of conceptual understanding, allowing the assessment of knowledge and
formulating higher-level and appropriate questions at different stages of the assessment, both during teaching and learning processes and in examinations [2].

In this perspective, the Bloom’s revised taxonomy [3] has been used to assess the contents, including the textbooks PA (e.g. [4-8]). Other studies, have been focused on the importance of the role of PA in teaching and learning science in a school context (e.g. [9-12]).

In order to identify some conditions associated with the development of scientific literacy in the scope of an Education for sustainability (ES), this study was centred on the cognitive level assessment [1] of textbook PA. Thus, the main goals were: 1) to identify the textbooks with the highest number of high cognitive level PA; and 2) to analyse and compare the PA distribution in the 2007 and 2014 textbooks, according to the cognitive level and the publishing house. Furthermore, this study was exploratory, descriptive and comparative, with respect to the description [13], with the main focus being the analysis of the proposed PA typology in textbooks.

2 METODOLOGY

2.1 Characterisation of the sample

The sample consists of ten NS textbooks of the 8th grade, of Portuguese middle school, designated by A, B, C, D, E, F, G, H, J, five edited in 2007 and five in 2014. Altogether, four publishers are represented, since two have more than one textbook under analysis. Sampling was of the non-probabilistic type, from a universe of NS textbooks approved by the Ministry of Education. The selection of the textbooks was based on data provided by the Ministry of Education and corresponds to the most used in Portuguese schools in 2013/2014 and 2016/2017 school years. The textbooks edited in 2007 were based on the Curricular Guidelines [14] and those published in 2014, on the current Curricular Goals [15].

2.2 Instruments and procedures

In order to achieve the proposed goals, PA registration and evaluation grids were built according to the cognitive level of the Bloom’s revised taxonomy [3], integrating six categories (remember, understand, apply, analyse, evaluate and create) of the cognitive processes dimension [13]. The definition of categories was adapted from Allen and Tanner [4] and the examples of PA were those described by Crowe, Dirks and Wendertoth [2].

The PA considered, besides being the ones proposed throughout the text of the selected curricular unit, ”Sustainable management of resources", and at the end of each subtopic/subdomain, are those that have been carried out, more often, in the classes.

The official documents and the textbooks were analysed in two phases and four moments. In the first phase, a two-moment analysis was performed, individually and together. In the second phase, the grids were filled in two moments, individually and together. At moment two, of the first and second phases, individual data were compared and an analysis was done in not corresponding cases to find a consensual solution.

The procedure involved content and quantitative analyses, being in mind that a content analysis always has a certain degree of subjectivity, on the part of the researcher, that can influence the achievement and the analysis of the information [16].

3 RESULTS AND DISCUSSION

3.1 Classification of practical activities in the textbooks, according to the cognitive level of the Bloom’s revised taxonomy (adapted from Krathwohl [3])

The results revealed an increase in the number of high cognitive level PA in the 2014 textbooks. Similar results were obtained in other studies (e.g. [17-21]). However, on the “Analyse” category, from the same cognitive level, it should be noted that textbooks H and J do not display any PA and textbooks G and I have only the minimum value (n=1) (Table 1).
Table 1. Classification of practical activities (PA) (frequency) of the Natural Sciences textbooks of the 8th grade in the theme “Sustainable management of resources” according to the cognitive level of the Bloom’s revised taxonomy (adapted from Krathwohl, [3]).

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<td></td>
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<td>A* (n)</td>
<td>B*** (n)</td>
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<td>Textbook PA/CL L (Total) (n)</td>
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<td>Textbook PA/CL H and CL L (Total) (N)</td>
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</tbody>
</table>

|                      |          | F** (n)                  | G**** (n)               | H** (n)     | I* (n)      | J* (n)      | Total (n) |
|                      |          | 3                       | 1                       | 4            | 4           | 4           | 16        |
|                      |          | 5                       | 3                       | 2            | 4           | 2           | 16        |
|                      |          | 8                       | 1                       | 0            | 1           | 0           | 10        |
|                      |          | Textbook PA/CL H (Total) (n) | 16                  | 5            | 6            | 9           | 6           | 42        |
|                      |          | Textbook PA/CL L (Total) (n) | 45                    | 30           | 23            | 35          | 29          | 162       |
|                      |          | Textbook PA/CL H and CL L (Total) (N) | 61                  | 35           | 29            | 44          | 35          | 204       |

* Publishing house I; ** Publishing house II; *** Publishing house III; **** Publishing house IV

The textbook, F (n=16) incorporate a higher number of PA of a high cognitive level; while textbook B (n=51), stand out on the low cognitive level.

In this analysis, it was also demonstrated that: 1) textbooks A and C do not have any high cognitive level PA; 2) textbook B has the highest number of PA (n=35) in the low category, “Understand”; 3) textbooks H, I and J present a higher frequency in the high cognitive level, “Create” (n=4); 4) textbook F stands out because it includes a higher number of PA at the high cognitive level (n=16) (Table 1).

The number of low cognitive level PA, in both editions, is highest in the “Understand” category, followed by “Remember” and “Apply”. At this cognitive level, the number of PA did not change significantly, safeguarding the category “Apply” that, in the 2007 textbooks edition (n=11), is much lower than in 2014 (n=26) (Table 1).

A comparative analysis of the distribution of the high cognitive level PA on the textbooks belonging to the same publisher (D, E and F, H), showed that there was an increase in the PA frequency categories “Evaluate” and “Analyse” in textbook F. In textbooks A, I and J, from another publisher, there was an increase in PA, from one edition to the other, in all categories, except for “Analyse” on the textbook J, which maintains the frequency (n=0). Textbooks C and G, from publishing house IV, displayed an increase of PA in all categories (Table 1).

3.2 Classification of practical activities of the textbooks, according to the typology and cognitive level (adapted from Krathwohl [3])

Regarding the PA typology, the diversity is higher in the 2007 textbooks, because there are proposals of PA in all categories, contrary to the registered in the 2014 textbooks that do not have fieldwork PA (Table II).
## Table 2. Classification of practical activities (PA) (frequency) of the Natural Sciences textbooks of the 8th grade in the theme “Sustainable management of resources” according to the typology and cognitive level (adapted from Krathwohl, [3]).

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<tr>
<td>Typology/Level H and L (Total) (n)</td>
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PP-Pencil and paper; STSE-Science, Technology, Society and Environment; P - Project; I=Investigation; L- Laboratory; F - Fieldwork; D - Discussion; S - Suggestions; O - Others.

In 2014 textbooks, there was an increase in the total number of PA (n=204), most of which were pencil and paper. In this edition, there is a higher number of high cognitive level PA (n=42) when compared to the 2007 edition (n=19), especially in the pencil and paper typology (category Analyse), project (category Create) and investigation (categories Create and Evaluate) (Table II).

Both editions have a prevalence of pencil and paper PA in the “Understand” category, followed by “Remember” and “Apply”. There are no pencil and paper PA in the “Evaluate” and “Create” categories in the 2007 edition textbooks and in the “Create” category from 2014 edition. In both editions, the laboratory PA (n=2) were quantified in the “Apply” category; while fieldwork, present only in the 2007 textbooks, were classified in the “Evaluate” (n=2) and “Apply” (n=1) (Table II).

The number of hands-on PA (fieldwork, project, investigation and laboratory), in both editions, is low when compared to pencil and paper. In the 2007 textbooks, the hands-on PA are focused, mainly, on the high cognitive level, but it should be highlighted that the laboratory PA are non-existent on this cognitive level. On the other hand, in the 2014 textbooks, the distribution of hands-on PA is more balanced between the cognitive levels (high and low), because they exist in approach number. However, there is a clear discrepancy in the distribution of PA by category depending on the typology. The STSE exercises, in both editions, maintain the frequency (n=2), but in the 2007 edition these PA proposals are distributed by low and high cognitive levels.

The implementation of hands-on PA can promote the improvement of cognitive abilities of analysis, application and critical thinking, representing the categories of high cognitive level that involve the cognitive processes of analysis, evaluation and planning [21]. Investigation PA are considered difficult to implement, due to the curriculum requirements and limitations of teachers’ knowledge and experience [22], but they are still suggested by the authors of the textbooks.

## 4 FINAL CONSIDERATIONS

Regarding the distribution of PA, according to the cognitive level, in the curricular unit studied, the results revealed the existence of differences between the 2007 and 2014 textbooks. The proposal of high cognitive level PA, in all three categories, is higher in the 2014 textbooks. Thus, an effort is made...
to include PA proposals at this level, that are conducive to a more autonomous and self-regulating learning. However, there was also a slight increase in the number of low cognitive level PA in the “Apply” and “Understand” categories. It should be highlighted that any textbook incorporates a higher number of high cognitive level PA, when compared to low cognitive level. Despite the importance of low cognitive level PA, those of high cognitive level are important for the expansion of complex intellectual skills [4, 23], particularly the development of critical thinking and problem solving skills.

For both editions, the results pointed to a prevalence of low cognitive level PA (remember, understand and apply) and a reduced number at the highest levels (analyse, evaluate and create) that can be justified by the ingrained idea that the student needs to be “trained” and then subjected to a summative evaluation, instead of a formative assessment.

Concerning the PA typology, the diversity is low with prevalence, in both editions, of pencil and paper. In the 2014 textbooks, compared with those of 2007, there are more proposals for project and investigation. On the other hand, laboratory and STSE PA maintain their frequency in both editions and fieldwork are none in the most recent editions. These PA (laboratory, STSE and fieldwork) can promote the ability to observe and solve problem, develop a critical spirit and deduce new principles associated with the development of scientific literacy in the scope of ES.

In the current context of SE, the high cognitive level PA are the most relevant [23] to promote the improvement of thinking skills that require metacognitive reasoning, such as establishing assessments and decisions. Thus, considering that the quality of teaching resources, such as textbooks, is important to achieve the goals recommended in the SE, we propose that a larger number of high cognitive level and laboratory/STSE/fieldwork PA, providing students with a greater cognitive involvement, should be included in the future editions of the textbooks.

Moreover, to provide students with PA that stimulate and promote the development of skills of different cognitive levels, it is also important that teachers analyse critically the PA proposed in the textbooks, to identify the gaps in the textbook adopted in their school.

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REFERENCES


Textbooks analysed


