Fronteiras: Journal of Social, Technological and Environmental Science
http://periodicos.unievangelica.edu.br/fronteiras/
ISSN 2238-8869

FRONTEIRAS

OPEN ACCESS

Article

Raising Children's Awareness about the Role of People on Supporting Sustainable Rural Land Use – Insights from Brazilian "Farm-School" Education Project

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ABSTRACT

We proposed and evaluated a new approach ("Farm-school project") to develop children's awareness about the role of people in agricultural production and environmental quality. The materialization of the "Farm-school" project was performed by a theoretical-practical 4-hour visit at an experimental farm. 240 Elementary school students were evaluated through concept maps and drawings, before and after the visit. There was a conceptual evolution in concept maps of 41 and 82%, and an increased number of categories per drawing of 23% and 37%. In concept maps, students did not relate people to the different spheres of agricultural production before the farm visit, but after, people became the main element. After the visit, students began to portray not only productive aspects in their drawings but also processes involving production, such as soil conservation practices and maintenance of mulch for soil cover. With the population concentrated in urban areas, there is a lack of contact with the rural landscape, generating a distorted view of food systems and rural land use, which affects social drivers and pro-environmental behavior. This imposes an educational task on governments to bring about information on agricultural production to elementary school students. We have proven the effectiveness of the "Farm-School" project as a low-cost educational policy alternative and a tool to increase children's awareness about the role of people in agricultural production and environmental quality since students come to a better understanding of where food comes from and how it is produced.

Keywords: environmental education; environmental quality; concept maps; public policies; society and environment.

RESUMO

Propusemos e avaliamos uma nova abordagem ("projeto Fazenda na Escola") para conscientizar as crianças sobre o papel das pessoas na produção agrícola e na qualidade ambiental. A materialização do projeto "Fazenda na escola" foi realizada por meio de uma visita teórico-prática de 4 horas em uma fazenda experimental. 240 alunos do ensino fundamental foram avaliados por meio de mapas conceituais e desenhos, antes e depois da visita. Houve evolução conceitual nos mapas conceituais de 41 e 82%, e aumento do número

Submissão: 01/06/2022 Aceite: 12/09/2022 Publicação: 30/12/2022

v.11, n.4, 85-103. 2022 • p. 85-103. • DOI http://dx.doi.org/10.21664/2238-8869.2022v11i4.p 85-103.

de categorias por desenho de 23% e 37%. Nos mapas conceituais, os alunos não relacionavam as pessoas com as diferentes esferas da produção agrícola antes da visita à fazenda, mas depois, as pessoas se tornaram o elemento principal. Após a visita, os alunos passaram a retratar não apenas aspectos produtivos em seus desenhos, mas também processos que envolvem a produção, como práticas de conservação do solo e manutenção da cobertura morta. Com a população concentrada nas áreas urbanas, há falta de contato com a paisagem rural, gerando uma visão distorcida dos sistemas alimentares e do uso do solo rural, o que afeta os motivadores sociais e o comportamento pró-ambiental. Isso impõe aos governos uma tarefa educacional de levar informações sobre a produção agrícola aos alunos do ensino fundamental. Comprovamos a eficácia do projeto "Fazenda na Escola" como uma alternativa de política educacional de baixo custo e uma ferramenta para aumentar a conscientização das crianças sobre o papel das pessoas na produção agrícola e na qualidade ambiental, pois os alunos passam a entender melhor de onde vem os alimentos e de como é produzido.

Palavras-chave: educação ambiental; qualidade ambiental; mapas conceituais; políticas públicas; sociedade e meio-ambiente.

1. Introduction

Agriculture provides most of the raw materials that feed, dress, heat, light, transport, and care for the health of almost 8 billion people worldwide. According to data from the Food and Agriculture Organization of United Nations (FAO 2015), the number of people living in large cities has increased disproportionately in relation to those living in the countryside. Until 2008, the world's rural population surpassed the urban population, and after this time mark, the picture was reversed. From 1990 to 2014, while the total world population grew by 36%, from 5.3 to 7.2 billion inhabitants, the rural population increased by only 11%, from 3.0 to 3.4 billion inhabitants. This disproportion has led, over time, to a distancing from the rural productive environment by people living in urban areas, which resulted in a lack of knowledge about how food is produced and where it comes from. It is common to find people who have not yet had contact with a ranch, a farm, as well as who have not experienced the opportunity to witness a pig, an ox, or even a chicken in a rural environment. Thus, people are unaware of the reality of agricultural production.

The unfamiliarity of men's role in agricultural production and environmental quality results from the dissociation between nature and men over time. This scenario was shaped by the industrial and scientific revolutions, and the expansion of human occupation where a culture transformation into a civilizing process took place, and the opposition between culture / civilization and nature has been established (Herculano 1992; Dustin et al. 2009). This distance between men and nature was followed by resulting imbalances, such as the uncontrolled population growth in large cities, unplanned dumping grounds, excessive pollution, rural exodus, diseases. In addition, the creation of an androcentric and dominating civilization that puts nature at the service of men, who exploited it wildly caused environmental degradation (Boff 2015). In its eagerness to follow what media trends dictate, globalized consumer society, creates a demand for a myriad of new products. Therefore, the pressure on natural resources has increased as people surrender to consumerism, which generates market distortions in the name of happiness and convenience (Pinotti 2016).

Socio-environmental problems take on intercontinental proportions, triggering discussions of global scale permeating the international agenda. In this context, environmental education is seen as a means of facing the challenges posed by the current environmental crisis (Silva et al. 2012a; Otto and Pensini 2017). Environmental education develops and improves attitudes, values, and environmental knowledge, in addition to developing skills that prepare individuals and communities to undertake positive environmental actions in collaboration (Ardoin et al. 2020). Environmental education should favor and stimulate possibilities to collectively establish a new alliance between men and nature so that all species, including human beings, coexist and survive with dignity (Shooter and Furman 2014; Reigota 2017). One of the ways to face environmental problems is sustainable consumption (Silva et al. 2012b; and Mutz 2014), which can be worked on by reconsidering (in the sense of renouncing common sense) the theme of conscious consumption in teaching practices, especially in environmental education actions (Mutz 2014); and by questioning irresponsible consumption and a better understanding of how the so-called eco-capitalism is based on the production and accumulation of uselessness and the disposability of products (Silva et al. 2012b).

Ecological awareness, which first of all demands education, requires an enabling environment for studying, adequate stimulation, access to balanced food, access to information and available time (Pinotti 2016). In this regard, environmental education contributes to individuals becoming an active part in society, learning to act individually and collectively in the search for solutions (Reigada and Reis 2004; Bamberg and Möser 2007). In fact, there is an increasing demand for actions of environmental education that embraces more information about the productive systems so that sustainability actions are more effective in the near future, aiming to improve individual market choices, in order to consider both positive and negative impacts implied in the act of consumption (Silva et al. 2012b; Mutz 2014). When environmental education begins with students in the first educational grades (cycles in Brazil), it leads these students to be aware of the importance, purpose, potential usages, and pertaining limitations attributed to the natural resources of planet earth; it favors the formation of individuals with a critical sense and keen scientific knowledge to make sustainable decisions in the use and protection of the environment (Guimarães et al. 2013; McKinnon 2017). Furthermore, students who participate in environmental education actions or disciplines demonstrate greater global awareness and ability to make more connections amid other fields of study (Ardoin et al. 2018).

Based on the statement that agricultural production knowledge is part of environmental education and that it is essential to face the challenges of the current environmental crisis, the objective of this work was to propose, evaluate and validate an environmental education project for elementary school students, characterized as a low cost and fast execution initiative, to raise awareness of the role of man in sustainable agricultural production.

2. Methodology

2.1. Elaboration of the "Farm-School" Environmental Education Project

The "Farm-school" project ascended from the need of bringing knowledge about sustainable agricultural production and care for the environment to elementary school children, creating an opportunity to showcase the reality of a rural property adopting a sustainable environmental-friendly land use system. The project consisted of taking students on an educational visit to the experimental university farm located in an Environmentally Protected Area, Curitiba water reservoir.

The "Farm-school" project's pedagogical goal was to bring children closer to productive rural environment, familiarizing then with the understanding of the basic principles and practices of sustainable agricultural processes in the production of food (inputs and outputs). Additionally, the pedagogical approach aimed to popularize scientific and technological knowledge related to sustainable production and environmental protection through environmental education, stimulating students' curiosity.

This project was supported by two pillars (Tobin 1993):

i) Strategic partnerships: focusing on co-participation in planning and execution;

ii) Action-oriented learning: for action based on constructivist theory (i.e., people build knowledge and infer meaning of concepts through experience):

- Strategic partnerships: seeks the cooperation of federal, state, and municipal institutions in order to use pre-existing and complementary infrastructure and human resources needed to materialize the project.

- Action-oriented learning: role of teachers in supporting self-directed action and experiential learning in authentic situations by students, in this case when visiting the farm.

Initially, "Farm-school" project was established as university extension activity. A partnership was formed with the Municipal Administration of Curitiba and with Curitiba's public schools that showed interest in taking their elementary students on an educational visit to university experimental farm. This co-participation allowed the project to be a low cost initiative since the following pre-existing structures and human resources were used: i) the educational visit took place at university experimental farm area that has environmentally protected areas and several agricultural systems previously set up by government-funded research projects, requiring no extra resources; ii) teachers and post-graduate students were the project actors, who included it as part of extension activity (this type of activity is already listed among the commitments of teachers and post-graduate students when granted with a government scholarship, thus requiring no extra remuneration to execute the project's activities); iii) school buses used to take the students to the farm visit were freely provided by the Municipal Administration of Curitiba; iv) office supplies for didactic purposes, such as sheets of paper, pens, were provided by the schools.

After the co-participation with the schools was established and the itinerary and the date of farm visit were defined, the activity followed the took steps (figure 1):

1 - A university graduate researcher enrolled on the Post-Graduate Program in Plant Production was responsible for the project design, implementation and evaluation. The researcher visited the participating school informing the students that they would visit a farm located in an Environmentally Protected Area located near the water reservoir that supplies the city of Curitiba, and there, students would witness and experience important agricultural production processes.

2 - The students went to the farm by bus, and during the trip the university graduate student explained what an Environmentally Protected Area is and how agricultural production is carried out there compared to a farm located outside an Environmentally Protected Area, underlining that care with environment are especially focused on soil protection and water conservation.

3 - Upon arriving at the farm, students learned about 5 sectors: i) sheep and goat production; ii) dairy cattle; iii) the highest point of the farm (to have a broad view of the processes as a whole and the water dam that supplies the city of Curitiba); iv) organic horticulture; v) planted forest. At each of these locations, they were accompanied by a university postgraduate student, and had the opportunity to touch, feel and interact with animals and plants, and received explanations from other students and postgraduate professors in plant production responsible for each sector (detailed roadmap at item 2.2 – Details of "Farm-school" project execution). At the end of the visit, still inside the planted forest, children were encouraged to play among the trees through games and contests.

4 - On the way back to school, feedback was given to the students and their questions were answered about what they learned on the farm.

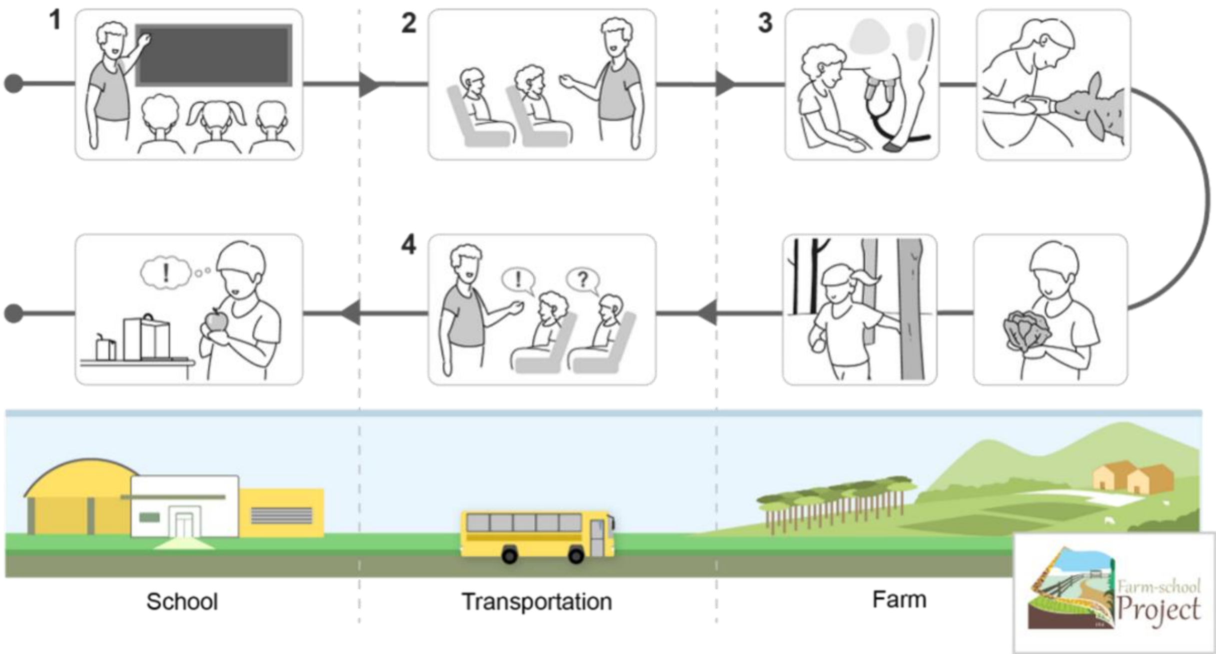

Fig. 1 – Infographic of the "Farm-school" project showing the 4 steps for the execution of the project.

2.2 Details of "Farm-school" Project Realization

The extension activity proposed by university entitled: "I Educational Visit of Elementary School students from the 4th to the 5th grade to the Farm-school Project", took place from May to July 2017 at experimental university farm located in an Environmentally Protected Area (see photo collection – SuppInfo).

A total of 240 children from 4 schools of the municipal education system in the city of Curitiba-PR, aged from 8 to 10 years old, participated in the extension activity. 129 students enrolled the 4th grade, and 111 students the 5th grade, which correspond to II cycle of fundamental education in Brazil. All children attended school in two periods, one with curricular activities and the other with educational practices after school hours, including the discipline of environmental practices. This discipline assumes an ethical view of personal and social responsibility related to the environment and sustainability, and should contribute to the search for alternatives to socio-environmental problems, insofar as it considers the student as a modifying agent of their immediate reality (Curitiba 2016).

The activity lasted 4 hours, considering 1-hour of travel time and 3-hour visit for each class composed of an average of 27 students. The students were guided by a university postgraduate student, and a group of 1 to 2 university professors, and 2 to 3 postgraduate students accompanied and interacted on each visit. A total of 5 university professors and 7 postgraduate students were involved. The activity followed the script established in the "Farm-school" project (see figure 1).

In the week prior to the visit, at their own school, students were instructed and informed about their participation on the farm visit activities in order to get to know it and learn more about how food and other inputs are sustainably produced. During the proposed activities, students would visit several examples of agricultural production, from dairy cows, sheep, goats, horticulture, planted and natural forest. On the day of the visit, the children were informed about the characteristics of the local scenario on their way to the experimental university farm. They were informed that university experimental Farm is in an Environmentally

Protected Area in order to protect one of the water reservoirs that supplies most of the Curitiba city water demand. It was underlined that in the area the use of pesticides is prohibited, and that all the production processes adopted there aim to protect the environment.

Once at the farm, students interactively participated in activities and they were welcome to comment and ask questions. The visit was carried out in 5 different locations on the farm: sheep and goat production, dairy cattle, the highest point on the farm, horticulture and planted forest. Each activity in the different locations of the farm lasted from 15 to 40 minutes, detailed as follows:

- The children got to know the generalities about the production of sheep, goats and dairy cattle, interacting and observing the animals (especially offspring). How the process of nutrient cycling occurs, how animal waste fertilizes the soil for plants, whether it is directly from animals' presence in a given area or with human interference (transport of manure to cultivated areas), were explained to them.
- The dairy cattle production, including the mechanical milking process of the cows, were observed. What corn silage is and how it is produced and stored (planted and fertilized with animal manure on the farm itself) were explained.
- The students were taken to the farm highest point so that they could see the main Curitiba water supply. At this point they were able to verify differences between heights and colors of trees, the riparian forests, the differences between the commercially planted forest and the natural forest, the unevenness of the land through which the streams run, the formation of the lake and the importance of the water dam, the reasons why it is not possible to use pesticides on the farm, as well as the possibility of agricultural production in an Environmentally Protected Area.
- The students visited the organic horticulture. They were able to identify and observe the species produced inside and outside the greenhouse. There was a demonstration of the irrigation system, to raise awareness of the importance of water in the survival and production of plants. Beneficial animals to plants, which serve as biological pest control, were identified. The importance of soil in agricultural production was discussed, emphasizing that it must always be covered and protected to maintain fertility and prevent erosion (one of the principles of conservation agriculture).
- The children visited the planted forest where they observed different species with the visualization of the characteristics of each one and explanation of their commercial use, contextualizing that if trees are planted there is no need to deforest native vegetation. They could observe the growth rate of the tree species that were planted at the same time at the planted forest site, which had different structures, diameters, and heights. They also saw the spatial distribution of the planted trees compared to the natural forest. Nutrient cycling was explained, from the beginning with the fall of leaves and branches, to the formation and decomposition of litter by the action of microorganisms, macro and mesofauna, absorption of nutrients by roots, until carbon sequestration through photosynthesis. Students were stimulated to look for small animals in the litter. They carried out the symbolic planting of a native tree species.

After each activity and on their return to school, students were encouraged to reflect on the possible final products of each sector visited and their importance to human kind.

2.3 Evaluation of the students participating in the "Farm-school" project

The children were evaluated twice: one week before and one week after the extension activity (farm visit). The test group, four 5th grade classes (corresponding to 111 children) and three 4th grade classes (77 children), took an evaluation right before and after the farm visit. The control group, two 4th grade classes (52 children), took the first evaluation, and two weeks later they took the second evaluation without having visited the farm (see photo collection – SuppInfo). Teachers from the schools of the evaluated students, once aware of the proposed activities, were advised not to work on any activity related to the visit theme in order not to influence the evaluation. They followed the advice.

The evaluation was carried out using two assessment tools: i) Concept Map - the students were gathered in groups of 3 individuals; they were trained and prepared their concept maps on a 60x45 cm blank sheet of paper, following the script proposed by Moreira (2013b); Torres and Marriot (2014); and answered the following guiding question: "how do you think a farm that produces our food and does not damage the environment would be?". Activity time: 30 minutes. ii) Drawing - on an A4 blank sheet of paper, individually, children were instructed to carry out the following activity: "On one side of the sheet, draw a farm that produces our food and that protects the environment; and on the other side, the same farm, but that does not protect the environment". Activity time: 20 minutes. The entire evaluation process was previously tested to define the method and guide its application to avoid any experimental errors.

2.3.1 Evaluation of concept maps

To analyze the maps prepared by the groups of students participating in the study, the methodology proposed by Yoval et al. (2006), Structural Analysis of Concept Maps using the Olmstead-Tukey test, was adopted. The methodology consists of transforming the concept map data into an association matrix, in which each pair of concepts with an existing valid relationship is assigned the value 1. In this analysis, the concepts were categorized, and the most frequent concepts were used, among those freely chosen by the evaluated individuals.

In the association matrices, the concepts were ordered according to the frequency at which they were presented on the maps, providing the total number of relations observed in each concept (R) and the frequency of association (F) that was determined as the ratio between the total number of different relationships and the total number of relationships that would be possible. Thus, the concepts that are dominant (R and F greater than or equal to the medians), constant (R less than the median and F greater than or equal to the median), occasional (R greater than or equal to the median and F less than the median) and rare (R and F lower than the medians) were determined. For better interpretation and visualization, the matrix data were represented cartographically, created in R program version 3.1.3 (R Development CoreTeam 2020), using *ggplot2* package (Wickham 2016) for data plotting, *ggrepel* packages (Slowikowski 2020) to avoid overlaying the text, and the *cowplot* package (Wilke 2019) to plot the two graphs in the same figure.

For the structural analysis of concept maps using the Olmstead-Tukey test, the relationship between the concepts of the maps was verified and a total of 92 concepts were found, initially distributed in 20 categories. However, only the 14 most frequent ones were part of this study and are summarized in Box 1 – SuppInfo. Being considered as frequent, the ones having a relation to at least 2 concepts from different categories.

The original concept maps prepared by the groups of students evaluated were reproduced for presentation in this manuscript using the tool CmapTools ® (IHMC 2020).

Concept maps were also evaluated by comparing those produced before and after the farm visit. For this purpose, the methodology proposed by Novak and Gowin (1996) was used, which analyzes and punctuates the elements that constitute Ausubel's significant learning (Ausubel et al. 1980) as hierarchy (5 points for each valid hierarchical level), relationships (1 point for each valid proposition), cross-links (10 points for each valid crosslink between hierarchical levels or different branches of the map) and examples (1 point for each valid example) (Novak and Gowin 1996). Figure 2 illustrates this scoring system.

With the 240 students participating in this study, 76 groups were formed for the construction of concept maps, of which 59 groups refer to the test groups (36 groups of 5th graders and 23 groups of 4th graders) and 17 groups refer to control groups (4th graders). Data are available in a data repository (the source will be disclosed in the final version of the manuscript).

Statistical analyzes of the scores for each of the elements that make up the concept maps, as well as the total sum of the scores for these elements, were conducted with the statistical program R version 3.1.3 (R Development CoreTeam 2020). Homogeneity of variance and the normal distribution of residuals (normality assumption) were verified with package nortest (Gross and Ligges 2015), when not normal distribution data was logarithm transformed according to the boxcox test implemented in package MASS (Venables and Ripley 2002). Subsequently, the t test was conducted for two independent samples comparing the performance of the 4th and 5th grade in the first assessment (before going to the farm) to verify whether the level of education would have an influence on the children's previous knowledge. For most variables, a difference ($p \leq 0.05$) was found in the initial knowledge as a function of the level of education (only the hierarchy did not show any difference). Therefore, the comparison of the before and after farm visit for each variable was carried out separately for the 4th and 5th grade classes. Considering the numerical nature of the variables and that the same people are assessed twice (that is, data were collected before and after the visit) generating dependent variables and paired data, the paired t test was used with a significance level of 5%. The 95% confidence interval of the averages was calculated using the *Rmisc* package (Hope 2013).

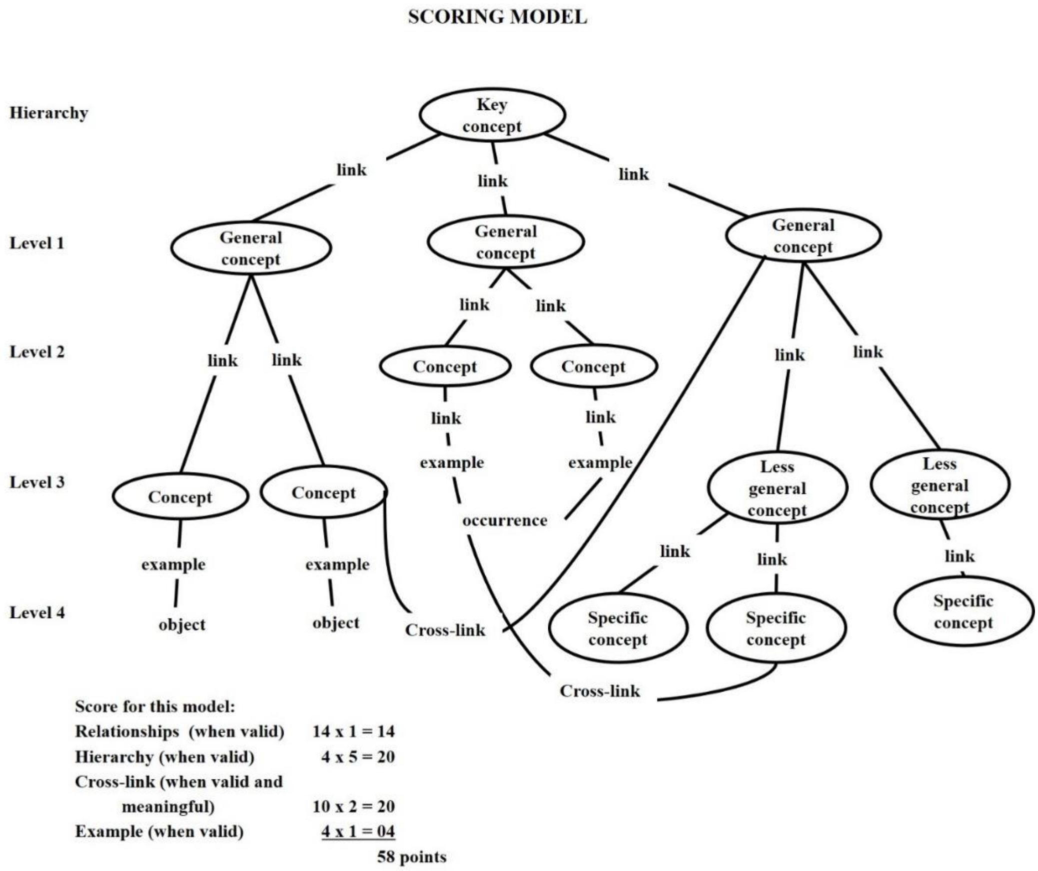

Fig. 2 – Scoring model for concept maps. Source: reproduced from Novak and Gowin (1996).

2.3.2 Evaluation Assessment of the students' drawings

The content of the drawings was analyzed and categorized, following the content analysis phases proposed by Bardin (2011), adapted for the present work. The child's view of a productive farm that cares for the environment was compared with the same farm that does not care for the environment. In the pre-analysis phase of the material or fluctuating reading, it was found that students tried to leave evident negative situations to differ a productive farm that takes care of the environment with the same farm that does not take care of the environment. So, on the selection phase of the units of analysis (or unit of meanings), these negative differences between the two types of farm were selected because they are relevant to the study proposal. The drawings were analyzed by comparing the child's view, and from this comparison the content categories were created. A total of 65 contents were found, initially distributed in 19 categories, but only the 15 most frequent ones were part of this study (Box 2 - SuppInfo). Categories were selected for presenting a minimum frequency of 2 occurrences between the two evaluation moments). Data are available in a data repository (the source will be disclosed in the final version of the manuscript). After categorizing the contents, the occurrences were counted in the drawings for each of the categories, and the t test was used to analyze the statistical differences between the occurrences before and after the educational extension activity, using the statistical program R as previously described in item 2.3.1.

3. Results and Discussion

3.1 Concept maps

Figure 3 shows the conceptual maps made by two groups of students and illustrate aspects of building the maps and conceptual gains. The authors of the maps of figure 3(A), 5th grade students, showed in the previous evaluation the following perceptions regarding the agri-food system: little knowledge about food production; the group was concerned with presenting the sequence of what commonly happens after the production of the food (from the farm to the final consumer); limited information about farm structure and components, such as the animal production, the presence of a river; aspects very close to common sense. Their unfamiliarity with productive processes was evident. In evaluation after the farm visit, these authors enriched their map, and presented a more elaborate knowledge, by placing people at the center of activities, illustrating the importance of water, soil, respect for animals and the purpose of agricultural machinery, which highlights their knowledge improvement regarding agricultural production processes that protect the environment.

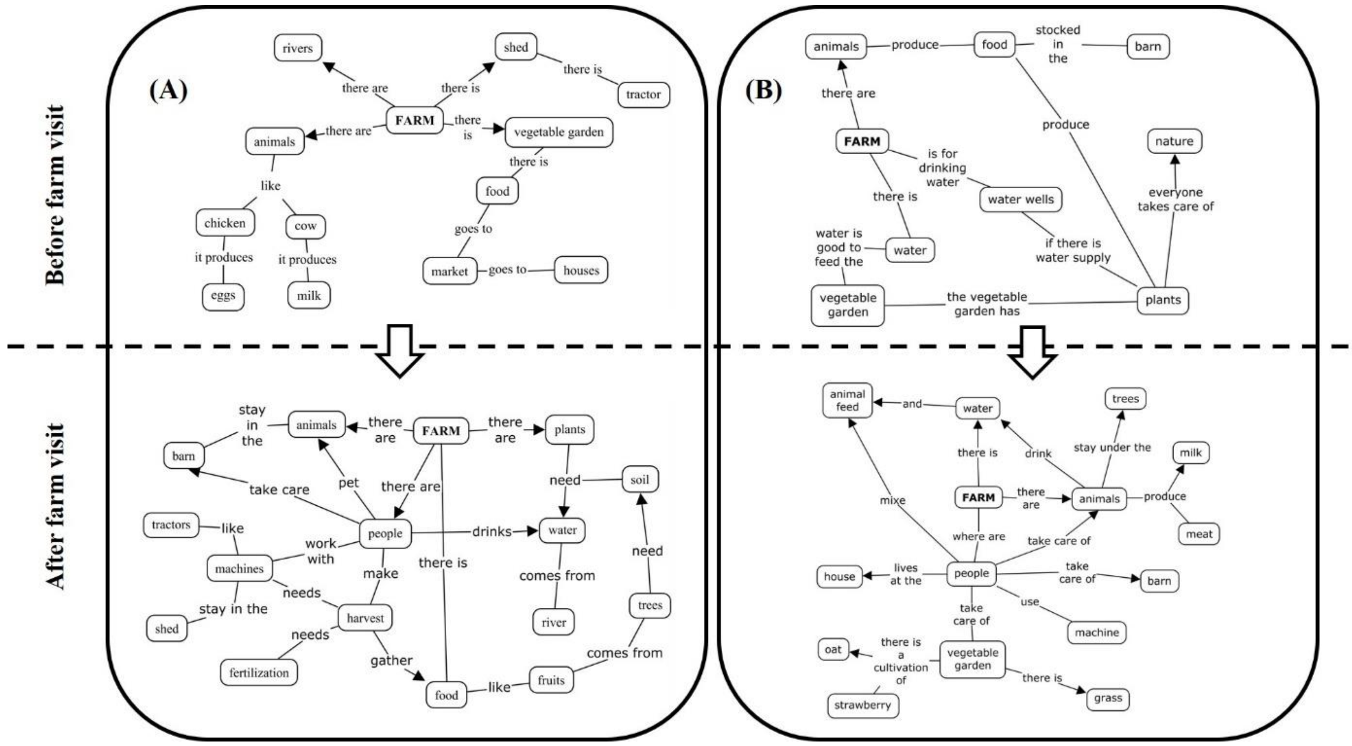

Fig. 3 – Concept maps prepared by a group of students from the 5th grade (A) and 4th grade (B) test groups before (upper maps) and after (lower maps) the educational visit at experimental university farm, regarding knowledge about sustainable production of food and inputs.

The authors of the maps in figure 3(B), 4th grade students, constructed their previous map with difficulty in expressing how a farm that produces food and protects the environment is, with an excess of connecting words in an attempt to explain the process and ideas closer to common sense, which is expected for 8- and 9-years old children, who have not taken direct contact with a farm. After the farm visit, many positive aspects were observed. This assessment revealed that students placed people at the center of the agricultural and food production processes; they demonstrated greater security in the construction of the map and aspects closer to agricultural production that protects the environment. Some interesting aspects were noticed in the concept maps: a vegetable garden producing grass and oats as cover crops (showing that they knew about the use of straw in gardens), as well as rearing of livestock under the shade of trees, presence of agricultural machinery and water use.

Analyzing the maps made by the children before the farm visit, it was noted that they have been drawn up with more simplistic ideas, demonstrating that children knew little about the farm routine. Even in this first assessment, maps showed that care for the environment is necessary for sustainable production. After visiting the farm, maps were richer in details. Knowledge expressed on them were more convergent to the reality of a farm, such as the participation of man as the center of activities, the use of agricultural machinery, the care for the soil and animals. Such results confirm the claims of Moreira (2013b) about concept maps as a good resource for a qualitative, subjective assessment, which seeks evidence of significant learning, and can be used to obtain a visualization of the conceptual organization that the learner attributes to a given knowledge.

In figure 3, aspects involving the construction of concept maps can also be observed. Children demonstrated they have acquired knowledge, increasing the number of hierarchical levels, valid propositions, examples, as well as valid cross-links. The increase in the elements of construction of concept maps, according to Novak and Gowin (1996); Moreira (2013a, 2013b), is an indication that significant learning has occurred.

According to the scoring system proposed by Novak and Gowin (1996), the concept maps produced by all groups of students were scored and the summary of the statistical comparison between the test and control groups is shown in table 1.

For the 5th grade test group, relationships and cross-links were the assessed elements with higher mean score in the evaluation after farm visit. Similarly, the mean score of the total sum of the map scores progressed from 43.4 to 61.5 points, representing a conceptual improvement of 41.7% after the farm visit. For the 4th grade test group, students' conceptual maps presented a significance increase in all assessed elements, with a higher mean score in the evaluation after farm visit and, therefore, higher sum of the map scores, demonstrating a conceptual progress in the order of 82.1%. For the control group, there was no increase in the score of any of the map elements, thus indicating no conceptual improvement.

The greatest difference among the assessed elements in the 4th grade test group was for cross-links. The frequency at which cross-links appear varied from 30.4% to 78.3% between evaluations, improving from 4.3 to 15.6 points (260% increase). The cross-links score of the maps from the control group was the same in the two moments of evaluation, this element was frequent in 52.9% of the maps at the first evaluation and in 58.8% at the second.

The conceptual improvement observed in the two test groups was probably due to the fact that the educational activities programmed for the visit on the farm provided pleasure and joy in learning. According to Moreira (2013a) when learning is significant, the learner has a good, pleasant feeling, he/she feels willing to new learning, and feels a cognitively growth. According to Reigada and Reis (2004), learning also requires pleasure and affection, which guide the individual towards conscious action. The children in the test group were motivated and wanted to be reassessed to express how much they have learned from the activities taken on the farm, reveling a scenario where students acquired knowledge that had a lot of meaning for them, a *sine qua non* condition for meaningful learning.

Data in table 1 demonstrates the importance of the activities developed during the farm visit to gaining new concepts by the students. Cross-linking, according to Novak and Gowin (1996) indicates creative capacity, which was observed in the structuring of maps, since children mentally explore the concepts learned, relating those concepts more safely after the activities developed on the farm.

Based on the definition of the categorized concepts (Box 1 – SuppInfo), relationships among them found in the concept maps were established. Association matrices were created containing the conceptual structure of the students' knowledge, before and after the extension activity on the farm related to the theme of sustainable production of food and inputs, as well as the medians of total relationships and frequency of association. From these matrices, data of the total of relationships among concepts (R) and the frequency of association (F) were represented cartographically, and are shown in figure 4 (for the 4th and 5th grades test groups). Quadrants represent rare (low R and F), occasional (high R and low F), constant (low R and high F) and dominant (high R and F) concepts.

Table 1 – Summary of the points obtained in the concept maps made by 76 groups of 240 elementary school students of 4th and 5th grade, before and after the visit at experimental universitty farm, according to the classification proposed by Novak and Gowin (1996).

Assessed Elements	Mean score (confidence interval)				p-value
	Before farm visit		After farm visit		
Test group - 5th grade					
Hierarchy (5 points)	13.2	(11.6 - 14.7)	15.1	(13.2 - 17.0)	0.1163
Relationships (1 point)	12.3	(10.9 - 13.6)	14.4	(13.0 - 15.8)	0.0263
Cross-links (10 points)	12.5	(7.6 - 17.3)	25.3	(20.2 - 30.3)	0.0003
Examples (1 point)	5.4	(3.5 - 7.3)	6.7	(4.6 - 8.6)	0.3762
CM sum	43.4	(37.3 - 49.4)	61.5	(55.2 - 67.8)	<0.0001
Test group – 4th grade					
Hierarchy (5 points)	12.4	(10.6 - 14.2)	15.0	(13.1 - 16.8)	0.0431
Relationships (1 point)	6.9	(5.8 - 7.9)	11.8	(10.2 - 13.3)	<0.0001
Cross-links (10 points)	4.3	(0.9 - 7.7)	15.6	(10.3 - 21.0)	0.0006
Examples (1 point)	1.3	(0.4 - 2.3)	3.0	(1.5 - 4.5)	0.0479
CM sum	24.9	(20.3 - 29.6)	45.4	(38.3 - 52.5)	<0.0001
Control group					
Hierarchy (5 points)	11.2	(9.2 - 13.1)	10.9	(9.5 - 12.2)	0,7939
Relationships (1 point)	7.6	(6.3 - 8.9)	9.9	(7.8 - 11.9)	0,0619
Cross-links (10 points)	8.8	(3.7 - 13.9)	8.8	(4.4 - 13.2)	1,0000
Examples (1 point)	7.1	(4.6 - 9.6)	4.9	(2.7 - 7.1)	0,1591
CM sum	34.8	(27.4 - 42.1)	34.5	(27.6 - 41.3)	0,9510

CM sum = sum of points of concept map elements: hierarchy, relationships, cross-links and examples.

The "animal" and "human" concepts, in the evaluation before the farm visit, were classified as dominant and remained as dominant after the farm visit, however, with a significant advance in the total of relationships, i.e. higher R. Such conceptual evolution is consistent with the focus given in the activities developed on the farm visit, when it was shown the valorization of the work done by farmers as well as the animal production, since students had the opportunity to visit and get to know sheep and dairy cattle. Therefore, it was natural for the assessed students to express in greater manner the relationships of these two categories of concepts, because according to Cuba (2010) knowledge of reality comes from the life experiences of individuals and their personal trajectories. Another conceptual gain observed in figure 4 refers to the concepts "soil" and "organic fertilization", which although discrete, changed from rare to occasional concepts, improving both in the total number of relationships and in the frequency of association (highest R and F).

For all these reasons, it can be said there was efforts were efficiently made to explain and demonstrate to children the importance of plants and animals in nutrient cycling, the use of wastes and manure as plant fertilizers, as well as nutrient cycling in planted forest environment. Reigada and Reis (2004) stated that, with the support of the teacher or a mediator, knowledge gain results from exchanges established between the environment (natural, social and cultural) and the subject, and becomes meaningful to the students.

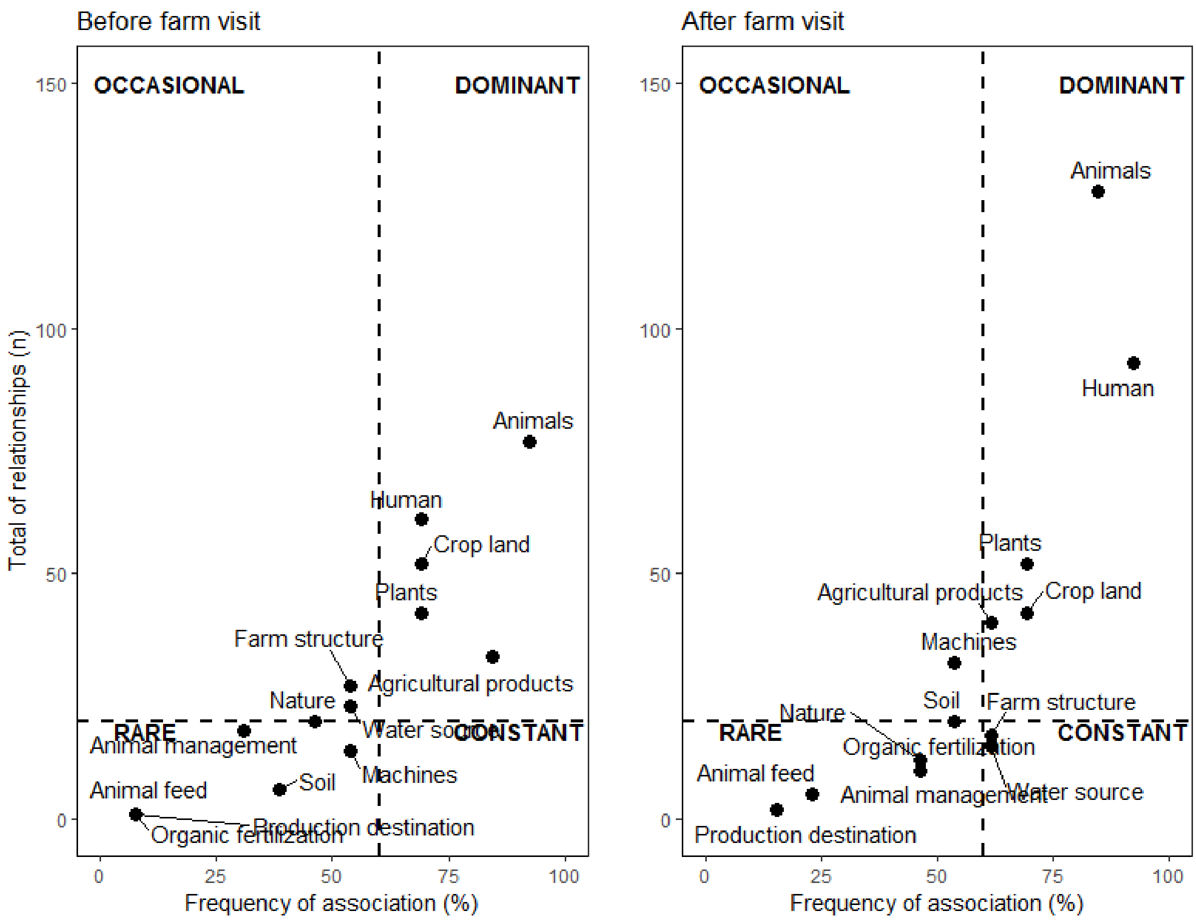

Fig. 4 – Structural cartographic analysis of the concepts obtained from 59 concept maps prepared by the test group students (4th and 5th graders) before and after the educational field visit at the experimental university farm.

Considering all conceptual maps constructed by both test groups (4th and 5th grades), a total of 376 concepts relationships were observed before the farm visit, and 488 relationships after the farm visit. For the control group, all conceptual maps made accounted for only 91 relationships in the first evaluation and 95 in the second one. These results expressed a higher richness of information in the concept maps after the intervention with the test groups, corroborating with Moreira (2013a), who states that new knowledge is built upon previous knowledge, giving learners greater stability, clarity and richness in meanings, expanding the repertoire of relationships among concepts.

Considering the children's conceptual maps as a whole, the conceptual evolution observed in the results obtained, it is possible to state that there was significant learning by the students. In the second evaluation, after farm visit, students from the test group built their maps in compliance with the assumptions of significant learning defended by Moreira (2013a), incorporating new knowledge with meaning, understanding and the ability to explain concepts.

3. 2 Student Drawings

The effects of the farm visit on the students' knowledge are evident in the drawings, as those presented in Figure 5. Before the farm visit, as in the example (Fig. 5A), students' drawings portrayed the common sense expected for children of their age, who are unaware of the reality of sustainable agricultural production. This lack of knowledge was expected to be observed, since a more urban way of life reduces the perception of the rural environment, as found by Marczwski (2006). In his study, comparing the environmental perception of elementary school students from the 5th to the 9th grade of a school located in a rural area with another located in an urban area (State of Rio Grande do Sul - Brazil; n = 259 students), he observed that students from the rural school had a greater environmental perception on the aspects: "agricultural products" and "conditions for agriculture".

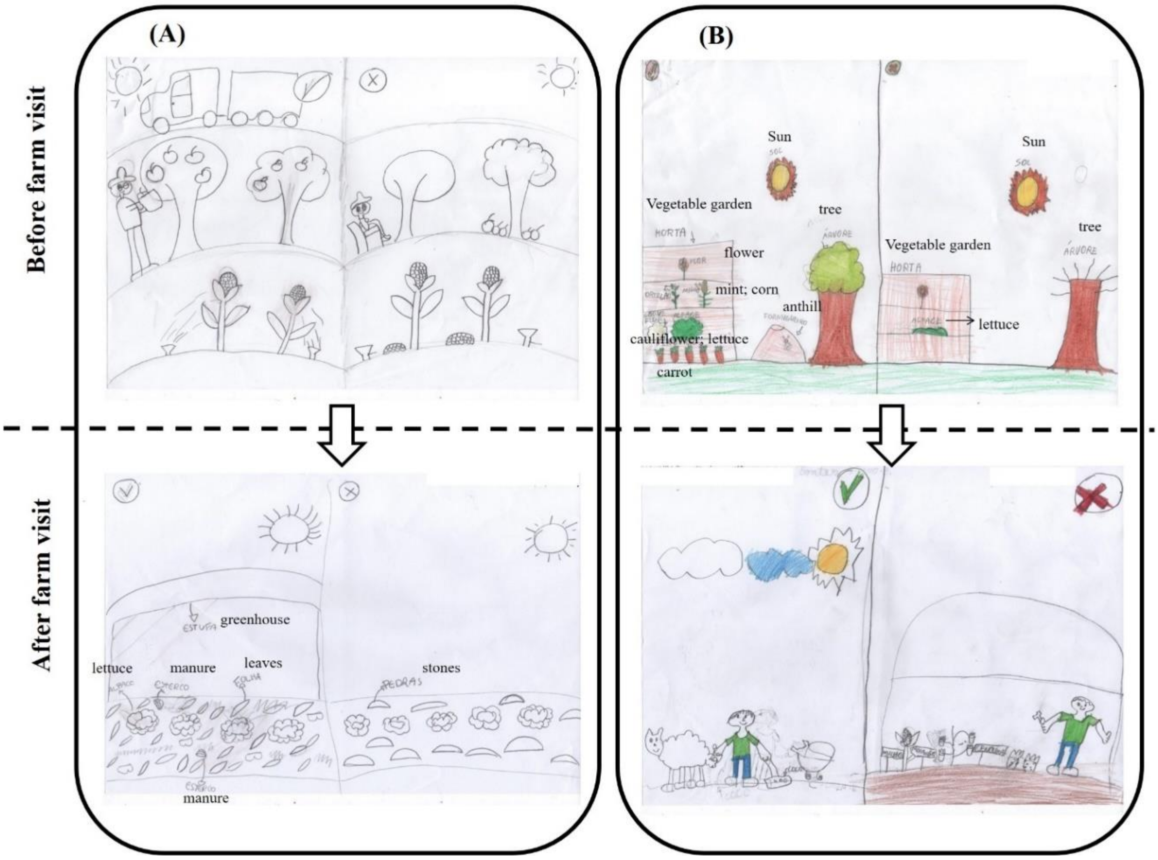

Fig. 5 – Drawings made by two elementary school students from the test groups – a 5th grader (A) and a 4th grader (B) - before (upper drawings) and after (lower drawings) the farm visit. The symbol "✓" made by the child, indicates the farm that protects the environment, and the symbol "✗" indicates the farm that does not protect the environment. Portuguese terms made by children are written in English next to each word.

In the present study, after the farm visit, students' drawings considered sustainable and protective productive processes towards the environment. The author of Figure 5A, before the visit, described the farm that does not take care of the environment, with a farmer not working but sitting, fallen fruits, no irrigation, and no harvest. Subsequently, the same student showed that the farm which produces sustainably has its own structure (greenhouse), takes care of the soil avoiding its exposure to weather variations, the use of manure as plant fertilizer, and the use of mulching. In figure 5 (B), the author showed, before the visit, that a farm that does not take care of the environment has indiscriminate deforestation and it is less productive. After the visit, the student showed that a farm that produces sustainable food takes good care of its animals, uses manure as fertilizer, and avoids production losses (black dots on carrots, indicating that they are rotten).

The result of the drawings content analysis shows the evolution of the students' knowledge after the farm visit, with an increase in the number of categories per evaluated drawing in the order of 37.2% and 23.5%, for the test groups of 5th and 4th grade, respectively. Control group did not show any difference between the two evaluation moments (Table 2). These results of the drawings analysis support the ones obtained with the concept maps, demonstrating the evolution of the children's knowledge after only one environmental education intervention.

Table 2 - Drawings contents average made by 240 elementary school students of the 4th and 5th grade from the city of Curitiba, before and after the educational visit at the experimental university farm.

Groups	Mean of drawing content per drawing (confidence interval)				p-value
	Before		After		
Test group - 5th grade	3.1	(1.78 - 4.28)	4.2	(2.64 - 5.75)	0.0481
Test group - 4th grade	2.6	(0.66 - 4.39)	3.2	(2.30 - 4.09)	0.0434
Control group	3.0	(2.44 - 3.75)	3.1	(2.19 - 4.07)	0.0761

Considering all drawings, the number of contents (according to the categorization shown in Box 2 - SuppInfo), that most varied between the two evaluation moments for both test groups (4th and 5th grade) were: "soil" - 271.4%; "idle farm" - 89.7%; "fire" - 60.0%; "water pollution" 52.6%; "natural resources" - 44.4%; and "animals" - 38.9%. In the previous evaluation of the 4th grade test group, there was no reference to the content "soil" in the students' drawings, it appeared in 16.9% of the drawings made after the farm visit. This helps to explain the wide variation of this content after visiting the farm, since "soil" corresponded to one of the most addressed topics discussed during the activities developed at the farm, focusing on soil protection essentiality as it is a main component of a sustainable production process.

3.3 Final considerations

Despite the fact that the present study was related to only one extension activity on sustainable agricultural production lasting 4 hours, data showed the efficiency of the interactive and stimulating proposal used in the farm visit. From the significant results found, it can be depicted that the children participated in the proposed activities with enthusiasm and interested in learning, which is according to Novak and Cañas (2010) and Moreira (2013a), one of the three requirements of meaningful learning, i.e., apprentices must be willing to learn. In addition, the other two requirements, conceptually clear learning material and relevant learner prior knowledge, were also met as the activities were offered in order to meet the evaluated students age range stage of learning, by adopting simple vocabulary and a motivational language approach. Regarding the previous knowledge, life experience and the content weekly work on the classes of environmental practices were considered as the students' previous knowledge.

The main role of environmental education is to help people adopt a new attitude towards their own place (Cuba 2010). Thus, in agreement with this author, and with the support of the results obtained through conceptual maps and drawings assessments, it was verified that knowledge assimilated during the farm visit experience enabled students to adopt this new attitude towards sustainable production of food and inputs, as awareness of the issues were developed focused on the student's interest in environmental preservation.

Finally, considering that the constructivist essays in environmental education, for allowing student physical contact and experience with the environment, are more effective (Shooter and Furman 2014), and assuming that in Brazil the lack of public policies and financial resources are two of the main obstacles for environmental education (Carvalho et al. 1999), the "Farm-school" project is a promising sustainable agriculture constructivist initiative and it is presented as a low cost educational alternative as the project aims to optimize the public investments already allocated to education, using structures and pre-existing human resources.

4. Conclusion

The evolution observed both in the results derived from the evaluation of the concept maps and the content analysis of the drawings demonstrates that students learned significantly. They were able to construct their conceptual maps according to the assumptions of the theory of significant learning, incorporating knowledge about the role of people on agricultural production and environmental quality with meaningful knowledge, understanding and explanatory capacity. This demonstrates the effectiveness of the "Farm-school" project, as a low-cost public educational policy alternative and a tool to increase awareness of elementary school students about the role of people on agricultural production and environmental quality.

This study reinforces the importance of offering educational activities *in situ* aimed at children, as it provides exceptional opportunities for learning, by allowing this audience to experience a constructivist essay that triggers spontaneous action of students in the search of building essential knowledge. Considering this approach, in all the agricultural systems visited, students converged to the theoretical and practical knowledge work on the projects activities, from the dairy system explanation to obtain milk to the discussion of soil conservation through conservation agriculture. The project provided to students the opportunity to nominally understand the social environment where the different systems are inserted as well as it offered the opportunity to notice how people in the different agricultural spheres interact in each system, which has contributed substantially, among other things, to the sense of citizenship and the development of these students' critical sense.

Acknowledgements

We thank Juliana Ferreira de Oliveira, graphic designer, Federal University of Parana, who created the infographic in Figure 1.

We thank Leonardo Bettinelli, web designer of the Support Foundation of the Federal University of Paraná (Fundação de Apoio da Universidade Federal do Paraná – FUNPAR, in Portuguese), who designed the logo for the "Farm-school" project.

Funding

This work was carried out with the support of the Coordination of Superior Level Staff Improvement (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - CAPES - in portuguese) - Financing Code 001.

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