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Appendix 1 Questionnaire

1: Strongly, 2: Fairty, 3: Evenly, 4: Not so, 5: Entirely not so

No.	Items	Scale
Q1.	Were you touched by heat generation from your own body-wormer?	**1-2-3-4-5**
Q2.	Did you have clear images about in and out of the substance accompanied by heat generation?	**1-2-3-4-5**
Q3.	Did you have clear images of overall reaction of rust of iron by the experimental kit?	**1-2-3-4-5**
Q4.	Was your knowledge is strongly coupled with facts of heat generation through making body-wormer?	**1-2-3-4-5**
Q5.	Select two items from those described below which maintain contents uplifting your feelings through the experiment! [Knowledge, Experimental & Observation Skills, Imagination, Creativity, Interest, Others]	
Q6.	Learning while bringing in making through is important !	**1-2-3-4-5**
Q7.	Select two items among those described below which maintain an importance for understanding chemical concept and/or phenomenon! [Knowledge, Skills, Experiment & Observation, Imaging, Making, Presentation, Debate, Others]	
Q8.	Select three items among learning methodologies described below which enhance your images! [Lecture, Experiment & Observation, Outdoor activity, Application of schemes, Making, Making reports, Presentation, Debate, Others]	
Free 1.	Free description; What ideas come to mind when you try to make body-wormer once again?	
Free 2.	Free description; Do you have any opinions through the experiment? [for example, want to take classes of yours, impressions actually made, relationship between knowledge and image and so on.]	

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The production of ecological paints as a contribution to the teaching of chemical concepts

La producción ecológica de pinturas como contribución a la enseñanza de los conceptos de química

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Abstract

This article aims to present the contributions of the subject's utility for the teaching of chemical concepts. The title of the project was "the production of paints from "soils" in the region of Ponta Grossa, in the State of Paraná – Brazil". The study was carried out with 16 students from the fourth-year of the Building Technician course at a state public school, in the discipline of Control and Environmental Protection. The methodological approach was qualitative with participant observation, whose techniques of data collection were images, testimonials, observation and notes of remembrance in field journal. The main results showed that there was a significant learning of chemical concepts worked in the production of paints from "soils". The analysis and interpretation of the values of density, and viscosity of each specimen resulted in acceptable values of standard deviation for most specimen. They also provided reflections on environmental implications in relation to the materials that are typically used in civil construction.

Key words: chemistry teaching, projects, ecological paint, viscosity.

Resumen

Este artículo tiene como objetivo presentar las contribuciones de los proyectos de utilización de la educación de los conceptos químicos. El título del proyecto es "La producción de pinturas del suelo " de la región de Ponta Grossa en el estado de Paraná - Brasil. El estudio se realizó con 16 estudiantes del cuarto periodo del curso de formación de Técnicos , como extensión del bachillerato en una escuela pública, en la disciplina de Control y Protección del Medio Ambiente. El enfoque metodológico fue de tipo cualitativo y observación sobre los participantes, la recolección de datos técnicas eran a través de imágenes, testimonios, notas de observación y en los diarios de campo. Los principales resultados mostraron que hubo un aprendizaje significativo de los conceptos químicos en la realización del proyecto de producción de pinturas con base en los suelos, mediante análisis y la interpretación de los valores de densidad y viscosidad de cada muestra producida. También se proporciona reflexiones de implicaciones ambientales en relación con los materiales que se utilizan comúnmente en la construcción.

Palabras clave: *enseñanza , química, proyecto, pintura ecológica, viscosidad.*

INTRODUCTION

Promotion of the construction of sustainable communities is the challenge of the 21st century (Capra, 2008), and consequently there is need for the training of professionals for civil construction, committed to the environment, aware that the city is the "nature transformed, an ecosystem, different, but not immune to its cycles" (Sirkis, 2008).

The work goals outlined here in the discipline of Control and Environmental Protection with the students of the 4th period of the Technical Course in Buildings subsequent to the high school level of a Public School aims to contribute to this training.

After the proposition of work for projects, carried out by the teacher, the students presented various topics with discussions and developed projects with alternative materials. One of these projects addressed the theme of the production of paints with less environmental impact and, after intensive research, produced paints from "soils" existing in the region. In this way it was possible to apply chemical concepts in the development of the project with "Ecological Paints", titled: "The production of paints from different types of "soils" that exist in the region of Ponta Grossa, in the State of Paraná - Brazil".

In the pursuit of knowledge of conventional paints the production paints based on "soil", it points out that the earliest records of the use of paints occurred in prehistory, in the form of rock paintings with pigments consisting of oxides of iron and manganese, carbon, micaceous iron oxide and carbonate chalk, mixed to water, bone marrow, animal fats, eggs, or plant sugars. Before the Christian era, linseed oil was already used, but was recognized in the 14th century and improved in the 18th century with new formulations, (Lambourne, 1999) and new characteristics (Bullett, 1999).

As Doroszkowski (1999) explains, paint is a colloidal dispersion of pigment in polymer solution (dispersant), i.e., a mixture containing binders, solvents and additives. The distribution of the particles, and the degree of dispersion influence on flocculation of pigment and its rheological dispersion (Strivers, 1999), the colored pigments absorb the light spectrum, increasing as the size of the particles is reduced, by intensifying the colors emitted (Bullett, 1999). The resin is the non volatile part, responsible for the formation of the pigment coat, strength and shine. Its generic purpose names the kind of paint, such as acrylic resins, epoxy, polyester, alchemical, vinyl and other (Abrafati, 2006; Farm, 2009). And, is embedded, forming a coat to preserve its dispersion (Bullett, 1999).

According to Adami (2002), other products are added to reduce its viscosity. As stated by Doroszkowski (1999) the amount of the solvent affects the amount of adsorbed polymer by the substrate and emphasizes the importance of the incorporation of electrolytes in emulsions and additives, as non agglomerate pigments tend to flocculate. Also used in the formulations are resins, solvents, pigments, dyes and other additives (Abrafati, 2006).

Pigments can be obtained from mineral, animal and plant sources and used for many applications. Experiments using pigments from different sources have shown good results in chemistry teaching. Lech and Dounin (2011), conducted activities with plant extracts and obtained different colors by changing the pH, helping students to understand the use of natural pigments and the interrelation between art and chemistry. A similar work was carried out by Jacobsen (2012). Experiments developed by Galloway, Bretz, Novak (2015), using anthocyanin extracts obtained from red fruits and grape vegetables were helpful to chemistry teaching in subjects like solid-liquid extraction, paper chromatography, characterization by UV/VIS spectroscopy and evaluation of antioxidant properties.

Activities in teaching chemistry concepts may be conducted using different methodologies, especially the perspective pedagogic projects. In this regard it is noteworthy that the pedagogy of projects sets the teaching/learning process: "Learning is no longer an act of memorization and teaching does not mean transmit ready digested content". (Leite, 1996). In this way, knowledge is constructed, becoming inseparable from the cognitive aspect, "You learn by living and interacting with the world. Not only answers are taught, but also experiences, and actions" (Leite, 1996).

Buck Institute for Education (1996) reinforces the understanding that learning through projects promotes learning, formulating questions that lead to the production of useful answers. The pedagogic mediation, in the cognitive universe, of clear intervention, ensuring the understanding of concepts and promoting interpersonal relationship is vital for learning from projects and it is a constant learning action (Prado, 2003) that can lead to significant learning that is understood as the result of the interaction between the new and the existing, resulting in a different cognitive structure (Ausubel, Novak, Hanesian, 1980).

As above, this study aimed to use in the teaching of chemical concepts projects producing paints based on "soils". The data presented are part of the dissertation research of professional master's in Teaching Science and Technology of the Federal Technological University of Paraná -Campus Ponta Grossa - Brazil.

METHODOLOGY

The methodological approach was qualitative with participant observation, data collection in notes on field journal started in 2013, with 16 students from the subsequent mode of the Building Technical Course of public school, using 10 classes of 50 minutes each. To preserve the anonymity of students, identification was made by letters (A, B, etc.) and the work was divided into three stages: 1) questioning, 2) development and 3) synthesis.

Stage 1: The questioning was the moment of planning and discussion in which we defined the production of paints and suggested the use of "soils" as pigment. Wood glue, water, and the "soils" were used, obtaining paints in the form of mixtures and colloidal dispersions probably with particles less than 1 micrometer.

Stage 2: The development of the project consisted in planning, collecting "soils", implementation and use. After collecting the "soils", they were dried in a flame and then crushed in a mortar with a pestle and sieved on nylon screens. After this, the paints were prepared using 11 different "soils", considering the stoichiometric calculation of 40 % of the formulation. 80 g of each of the dried and crushed samples were weighed in test tubes of 100 mL, using a digital scale accurate to one decimal place, and at the same time, the volume of each "soil" was measured to calculate the density ratio of each sample, then they were packed into beakers of 250 mL and solubilized with 100 mL of water, homogenized and added 20 mL of wood glue on base of polyvinyl acetate. After homogenization, and decanting a heterogeneous mixture was obtained with background body and supernatant solution for each type of "soil" and this led to different paints, ready for the evaluation of viscosity and application testing. Based on the characteristics of commercial paints and those produced in class, we addressed the chemical knowledge, mixtures, solute, solvent, colloidal dispersions, suspensions, solutions, mass, volume, stoichiometric calculation, density and viscosity, culminating in the analysis of viscosity using viscometers (Ford viscosity Cup).

The analyses were performed in triplicate, with number 2 viscometer and capacity of 100 mL of solution. The analysis consisted of completely fill each Cup Ford with the sample, leveled with the glass cane, keeping the hole in the cup covered. The outflow of each sample was released simultaneously with the activation of a stopwatch to record the time (Figure 1).

Stage 3: This way the synthesis stage which permeated the whole process until the completion and interpretation of the calculations using the outflow time of each paint for the determination of viscosities, standard deviations (SD) relative standard deviation (RSD). The approach of chemical concepts and the data obtained allow discussions about the sustainability and environmental issues.

RESULTS AND DISCUSSION

The paints produced showed different characteristics, with different colors related to the type of "soil", and arising from the physico-chemical composition of these materials as presented in Figure 1. According to Sá (2007), the "soil" of the region comprises of caolin, iron oxide and aluminum, with size less than 0,001 mm, clays with colloidal properties, and rocks named sandstones.

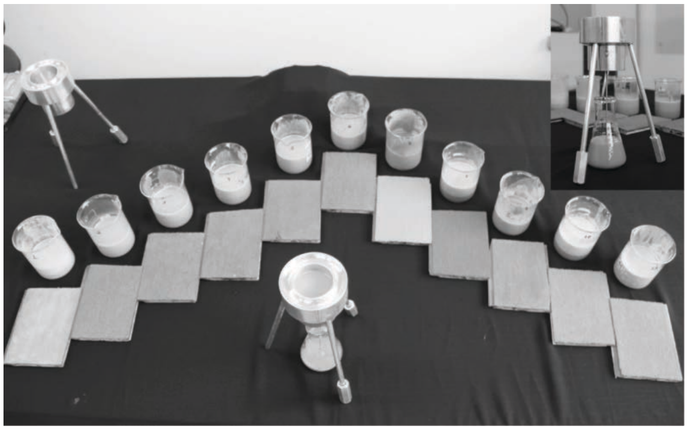

Figure 1. Viscosity analysis and application of paints obtained from different "soils"

The rock formations in the region are divided into sandstones: Furnas, Vila Velha, Lapa and Itararé Group rocks, of varied composition, being the main the quartz (silicon dioxide), iron-cement (oxide and hydroxide of iron), manganese iron sandstone (manganese oxide), and siliceous and clay minerals (caolin) (Melo, 2006).

The density of "soils" collected was determined using the values of mass and volume, and ranged from 888.88 $g.L^{-1}$ to 1333 g.L. It was observed that equal masses of "soil" resulted in a larger volume, influencing the characteristics of the formulations. It was inferred that the particle size correlated with the density of the "soil" as Strivers (1999).

In the statement of calculations of viscosity was used the sample number 4. The results of the viscosity values were calculated from the outflow time in seconds using formula 1, for the Ford Cup 2.

$V = 2{,}388 \,.\, t – 0{,}007 \,.\, (t)^2 – 57{,}008$ (Formula 1)

The outflow times of sample number 4 were, t_1 = 24"12 (twenty-four seconds and twelve hundredths), t_2 = 24"05 (twenty-four seconds and five hundredths) and t_3 = 24"12 (twenty-four seconds and twelve hundredths). Thus, using the formula 1, time 1 was obtained from 24"12 (twenty-four seconds and twelve hundredths), and the kinematic viscosity 1 (V_1 = 3,48 $mm^2.s^{-1}$).

Following the same criterion, were obtained times of 24"05 (twenty-four seconds and five hundredths), resulting in viscosity 2 (V_2 = 3,62 $mm^2.s^{-1}$), and for the time of 24"12 (twenty-four seconds and twelve hundredths), resulting in V_3 = 3,48 $mm^2.s^{-1}$. So, the average of the calculated viscosity was 3,52 mm^2/s.

The standard deviation was calculated and presented in Table 1, seeking an alternative so that the student use the reasoning of diagrammatic form.

The results of the calculations of the kinematic viscosity, standard deviation and relative standard deviation corresponding to each one of the formulations of paints are presented in Table 2. The viscosity of a suspension is dependent on interparticles forces, and Brownian motion, which increases as the particles approach, requiring greater time in relation to outflow (Strivers, 1999).

The viscosity values obtained ranged from 1.19 $mm^2.s^{-1}$ in sample 10 to 5,35 $mm^2.s^{-1}$ in sample 1, as a result of the different composition of each "soil" used, which gave specific characteristics to each solution as a consequence that the viscosity is related to the size of the ions and the electrolytic strength as Strivers (1999).

No *Ford Cups* were suitable for sample number 7, and that made it impossible for the evaluation of viscosity in this sample, however, all the other used the *Ford Cup* with the hole 2. The analysis of viscosity was important for assessing the quality of paints. The values of SD and RSD were acceptable for most, however, elevated to the samples 1, 8, 9 and 11.

Table 1 - Calculation of standard deviation for the paint sample number 4

Kinematic viscosity ($mm^2.s^{-1}$)	Differences between average and Viscosities of samples	Differences between the high viscosities squared $(\neq)^2$
V_1 = 3,48	- 0,046	0,002116
V_2 = 3,62	0,093	0,008649
V_3 = 3,48	-0,046	0,002116
Average = 3,52		$\sum(\neq)^2$ = 0,012881
	$SD = \sqrt{\frac{\Sigma(\neq)^2}{n-1}}$	

Source: Experimental data using the Ford Cup N°. 2

Standard deviation calculations were carried out using the following formula:

$$SD = \sqrt{\frac{\Sigma(\neq)^2}{n-1}} \qquad SD = \sqrt{\frac{0{,}012881}{2}}$$

$$SD = 0{,}08$$

The calculation of relative standard deviations were obtained using the formula:

$$RSD = \frac{DP \times 100}{average\ viscosity} \qquad RSD = \frac{0{,}080 \times 100}{3{,}52}$$

$$RSD = 2{,}27\%$$

So the result was obtained from Kinematic Viscosity equal to 3,52 $mm^2.s^{-1} \pm 0{,}08$.

Table 2 - Results of kinematic viscosity, standard deviation and relative standard deviation of the samples of ecological paints produced on base of "soil".

Paints	Kinematic viscosity ($mm^2.s^{-1)}$)	Standard deviation	Relative standard deviation (%)
01	2,12	0,355	16,70
02	5,35	0,12	2,36
03	4,37	0,01	0,23
04	3,53	0,08	2,27
05	5,13	0,19	3,60
06	2,83	0,02	0,49
07*	________	________	________
08	3,48	0,315	9,06
09	3,49	0,33	9,46
10	1,19	0,02	1,32
11	1,73	0,20	11,63

Source: Experimental data
** Values not presented due to the viscosity be superior to Ford Cups available (time of outflow > to 100s)*

In the course of activities were included the chemical content (solute, solvent, solution, colloidal dispersion, mixtures, suspension, density and viscosity) occurring learning as noted on the statement of Student A: "In relation to [...] practices, were very good, because the achievement was a lot better than if we had just had theoretic classes". Learning and the importance of the work were also found in the statement of Student B "From my point of view it was great learning, because I will take for the rest of my life the knowledge gained, and whenever possible I will take all these techniques for my future works".

The students' reports portray considerations of Leite (1996) when considering that the teaching by projects allows the student to experience learning, in which the knowledge-building process is integrated to the practices. Such participation of students, developing the experiments, and making decisions provides the development of entrepreneurs. Dolabela (2003) corroborates with the understanding that the entrepreneurial attitude is not innate and depends on including democratic and cooperative attitudes in the program.

The application experiments of the paints on wooden surfaces resulted in a good fixation of colors (Figure 1), even with different viscosities. And, according to the student L "It was possible to learn how to prepare the paint for painting walls, houses, etc. using land(soil), water and white glue, with the exact percentage of each ingredient, we get paint ready for use." It confirms what Moreira (2008) argued that learning with meaning and understanding, takes place interactively and that it depends on the existence of previous knowledge.

The student P said "The preparation of land-based paint gave us a sense of how it can become cheap and easy painting of a building, making this property more beautiful, valued and ecologically correct in relation to the ones painted with common material".

It can be affirmed that the project provided several reflections about the availability of cheaper technologies not available to the population, about the possibility contamination of water bodies, the improper disposal of waste, the unpreparedness of the professionals, and the resistance in accepting civil construction as part of the environment by reducing the environmental impact and also keeping the quality.

It was noted that the teaching by projects encouraged the students to develop experiences and build their knowledge, as noted on the statement of Student E: "We had the opportunity to research and discuss endless possibilities for making a beautiful and comfortable building and at the same time sustainable, small attitudes that help preserve and conserve nature".

The students spoke of the difficulties encountered when developing a project, highlighting the student J, "But on top of all the work there are difficulties, as well as finding exhibition materials, having to move material from neighboring towns [..]" and the student M added, "despite the difficulties the team is to be congratulated for having chased new ideas and so managed to complete the work".

By observing the attitudes and words of the students, it was found that they showed motivation and initiative at all stages of the process. Also, it was a very significant learning-friendly activity besides generating environments conducive to collaboration and cooperation, as Menezes and Faria (2003) observed in their work.

CONCLUSIONS

The realization of the work using the pedagogy of projects in the production of paints from "soils" allowed the students to understand and differentiate the chemical concepts of solution, suspension, gel, colloidal dispersion, density, viscosity from the experimentation, of carrying out the calculations, and the practical application. Enabled the understanding that viscosity is responsible for the fluidity of the paint and, for that reason, exact proportions should be used in the formulation, in addition to promoting the use of alternative materials in construction.

In addition, the development of this study provided great debate regarding the use of environmental-friendly paint as a low-cost option that maintains quality. It was possible to realize the motivation, involvement and initiative of the students.

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Studying the importance of soil organic matter: an educational proposal for secondary education

Estudiando la importancia de la materia orgánica del suelo: una propuesta educativa para educación secundaria

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Abstract

Although the importance of including in the curriculum of all educational levels issues related to soil science has been strongly highlighted, the fact is that the importance that the quality and availability of organic matter in the quality of soil has received very little attention when it comes to considering educational practices in classrooms. This paper brings an educational proposal for teaching the transcendence of organic matter in soil at secondary level. The learning unit presented is based on essential chromatography techniques and allows the qualitative study of soil organic matter. The ultimate purpose is to offer basic educational tools for reflection on the implication that soil has in order to maintain biodiversity and food production.

Key words: *teaching methods, undergraduate education, soil science, K-12 education.*

Resumen

Aunque la importancia de incluir en el plan de estudios de todos los niveles educativos cuestiones relacionadas con la ciencia del suelo ha sido fuertemente resaltada, el hecho es que la importancia de la calidad y la disponibilidad de la materia orgánica en el suelo han recibido muy poca atención cuando se consideraran las prácticas educativas en las aulas. Este documento aporta una propuesta educativa para la enseñanza de la trascendencia de la materia orgánica en el suelo en el nivel secundario. La unidad de aprendizaje presentada se basa en las técnicas esenciales de la cromatografía y permite el estudio cualitativo de la materia orgánica del suelo. El objetivo final es ofrecer herramientas educativas básicas para la reflexión sobre la implicación que tiene el suelo a la hora de mantener la biodiversidad y la producción de alimentos.

Palabras clave: *métodos de enseñanza, pregrado, ciencia del suelo, educación secundaria.*

INTRODUCTION

Soil is a complex, non-renewable and essential natural resource in the maintenance of ecosystems and it is also key to ensuring the food, energy and fiber supply to humans.

Soil organic matter comes from either the remains of living things which were once alive or their waste products in a natural environment. Once on the ground, organic matter undergoes a set of complex chemical transformations conducted by living beings in soil (Trevors, 1998)). Thanks to these chemical changes, organic matter gradually achieves a quasi-equilibrium state known as *humus* which can remain stable over time (Schmidt, Torn, Abiven, Dittmar, Guggenberger, Janssens et al. 2011, Tan, 2014).

What makes humus so important for plant life is that it is rich in humic and fulvic acids. These substances produce organo-mineral associations with ions such as Mg^{2+}, Ca^{2+}, Fe^{2+} y Fe^{3+} (Tang, Zeng, Gong, Liang, Xu, Zhang, et al., 2014) resulting in an increase in the availability of micronutrients to plants which is an essential feature of healthy and fertile soils.

However, secondary and high school level educational programs have paid little attention to this crucial factor closely tied to soil productivity (Bertha, & Leslie, 2002; Megonigal, Stauffer, Starrs, Pekarik, Drohan, & Havlin, 2010; Vila, Contreras, Fernández, Roscales, & Santamaría, 2001).

OBJECTIVE

On the basis of the above, this paper presents a practical proposal specially targeted for the laboratory of secondary education with the purpose of encouraging a vision of soil organic matter as a finite and vulnerable resource which is essential to sustain plant life, the environment and to the foodstuffs industry.

METHODS

The following is the teaching sequence proposed to achieve the previously highlighted objective. To this end, and as a form of an example, this paper presents a real study carried out with five soil samples.

First step: Sampling and sample preparation

The five soil samples analysed in this study were collected using a metal trowel to a depth of 10 cm.

First of al, the samples are left to air dry for three days on a white blank sheet of paper. Then, 150g of each soil sample is taken, without stones or plant debris and are sieved and ground with a mortar until a homogeneous powder is achieved. The final samples, duly sieved and ground, are stored in clearly labelled paper bags.

Second step: The impregnation of the stationary phase with light-sensitive substance

To continue with the experiment Whatman qualitative filter papers (grade 4) are required. In this case, 5 circular filters are to be used, one for each sample. With a pencil, two points will be marked on each filter, four and six centimetres respectively from the centre of the circle.

On another development, five small pieces of filter paper are cut (2cm x 2cm) and these filter pieces are rolled up to form small cylinders as a cannula or tiny tube. Finally, a hole is drilled into the centre of each filter and each of the previously created cannula is inserted perpendicularly through the holes in the centre of each filter.

The filter with the cannula lodged in the centre is placed on a Petri dish in which previously a 0.5% silver nitrate ($AgNO_3$) solution is poured (see photo 1).

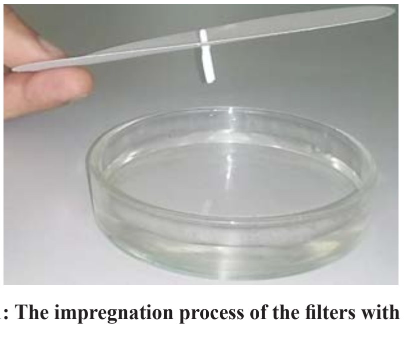

Photo 1: The impregnation process of the filters with $AgNO_3$