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Joseph wright and the ENCANTADAS Grotto: the potentialities of an interelation proposal for the teaching of science

Abstract

This article presents the results of a qualitative research, based on four paintings by Joseph Wright that portray a cave near Naples painted in 1774 and in the Grotto of the Encantadas-Ilha do Mel State of Paraná in Brazil. In order to promote scientific literacy and also visual literacy from image reading, we developed four didactic sequences for the teaching of sciences for the second cycle of elementary school based on the thematic caves. These sequences were applied to students after class activities at the João XXIII Institute, an institution that serves children at social and economic risk in the city of Ponta Grossa, in the interior of the State of Parana. Data collection took place through observation, audio recordings, photographic records and materials produced by students. The main findings showed that the use of Joseph Wright's art works and the photographs of Gruta das Encantadas in the didactic sequences was an effective strategy to provide scientific knowledge, develop image reading skills as a means to establish a connection between sciences and arts. The findings also show that the use of art works by Joseph Wright as strategy for classroom activities contributed for the development of students' creativity, rationality, and environmental awareness, by focusing specifically on the protection of cave environments and for meaningful learning in the scope of science and arts, as well as the interelation between these areas.

Keywords: Image reading, scientific literacy, problematization

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Introduction

This research was carried out in collaboration between the research group on art, science and technology of the Federal Technological University of Parana - Campus Ponta Grossa and the João XXIII Institute, a non-profit entity that for 40years has been assisting children and adolescents ages 6 to 18years in situation of social and economic vulnerability. It is located in the city of Ponta Grossa in the interior of the Paraná State - Brazil. The planning and implementation of the project lasted 1year and 3researchers/teachers and 11male and female students participated, ages between 12 and 15years old, they were all members of the public school system in Ponta Grossa, regularly enrolled in the final years of elementary school and these students alsoattended morning classes at Instituto João XXIII. The choice for this age group was due to the fact that they were exposed to the contents that were addressed during this research at their formal school. Elementary school years provide children with intellectual and moral development, consequently, it is the moment when they are in constant discovery of the world around them.

In elementary school, this is mainly provided through the science discipline, which encompasses three areas of knowledge with in the Brazilian curriculum: Chemistry, Physics and Biology. These disciplines in general have a large number of concepts that, at times, are simply memorized, thus never applied outside the pages of the textbooks, contributing for students to have difficulty in learning them and it also constrains students ability to articulate and use more complex theoretical knowledge within the reality in which they live. It is known that students are in constant contact with science and therefore, for science teachers, it is extremely important to think of ways to make the teaching of science accessible, understood in practice and applied to real contexts. In order to do this, there is nothing better than raising students' interest and challenging their participation by developing classroom activities that may trigger their interest in knowledge, and also provide them the opportunity to apply this knowledge outside the classroom. With this in mind, the teachers who participated in this research implemented various class activities divided in didactic sequences to work with image reading through the problematization of knowledge based on a generating theme.

It is expected that by problematizing knowledge based on a certain theme, it may change the way students react to new knowledge. Furthermore, students may then be challenged to apply this knowledge outside the classroom in more significant ways. In this study, in order to provide students this broader view of the world and of science, teacher relied on art works, more specifically image reading. By drawing on arts, sciences and by problematizing knowledge, teachers expected as results that students do more than simply learn the content, it was also expected for students to develop a critical sense in relation to the content they were exposed to, aiming at contributing for them to perform a more active role as citizens. This is very important in today's world, where it is necessary to participate in scientific, social and environmental decisions that may promote environmental change and impact future generations. In order to meet these expectations, the participating teacher acknowledged that the arts as well as science are based on observation and involve a creative process. Therefore, the teacher saw potencial in interalating the arts and sciences as classroom strategies in didactic sequences to teach content. According to the teacher, this strategy may contribute to students' formation by helping to develop the qualities that students need to go through their second cycle of elementary education, a determinant phase of life for personal formation, one which may influence how they will act in society in the future.

Aiming at scientific literacy, and visual development, this work involved reading the image of four art works by Joseph Wright and studying the Gruta das Encantadas-Paraná-Brazil, in order to develop students' creativity, sensitivity, awareness about science, nature, and about environmental issues through the caves and the aesthetic experience that art may provide. In addition, art is also part of a process of cultural construction that allows students to confront a reality that is different from their own, providing better social interaction, and personal development. Consequently, it may also provide them the opportunity to learn about other cultural isssues such as indiscipline and school violence, for instance. Within this perspective, this research was carried out with a group of students in a situation of social and economic risk who were assisted by Instituto João XXIII, a Catholic charity institution located in the city of Ponta Grossa, in the State of Paraná. In this work, we developed a didactic sequence with the thematic of caves, which is based on the dynamics of the three pedagogical moments and focused on the problematization through image reading. With the sequence developed, we worked on some of the contents of the science discipline planned for the second cycle of elementary education. The guiding question of this research is: What are the potentialities of a proposal for interelating the art works by Joseph Wright's caves and the Encantadas Grotto for teaching science? With these didactic sequences, the teacher expected to change common patterns of behavior regarding learning difficulties, disinterest, and conflicts associated to the reality of the students involved. Teachers also expected with this differentiated teaching proposal to promote scientific and visual literacy to improve the quality of the teaching/learning process in science, the creative process, artistic development and establish new relationships between students and the environment and the world that surrounds them.

Scientific and visual literacy from image reading

Images are very common in society, they have been part of human life since the dawn of humanity with cave paintings that served as a form of communication, and today they are present since birth. With such power of influence in people's lives and because they are capable of cognitively and creatively develop society. It did not take long before images were used as meaningful resources for teaching as well as for learning. However, images are so common to our eyes that we hardly stop and analyze the different elements that constitute them and how they may be used to construe knowledge. In the conception of Santaella[1] this is linked to the fact that at all times we live on the stimulation of images, and for this reason, it is normal to see them in a naive or intuitive way. In this sense, with regard to the development of interpretative skills, it is necessary to mention the importance of first developing the ability beyond "seeing", as well as "reading" the images in a process called "image reading". When we refer to the term "image reading", we refer to "acquiring the corresponding knowledge and developing the necessary sensitivity to know how the images present themselves [...] which is the context of reference, how the images mean, how they think, what are their specific ways of representing reality ".[1]

The process of image reading is wide and covered with possibilities, when we learn to read them. In addition, it is beneficial to the acquisition of knowledge, we are becoming visually literate, capable of interpreting the messages they transmit to us. Based on this idea, when developing a didactic sequence of activities that involves the process of "reading the images", the teacher may also contribute for the development of students in an interdisciplinary way. Knowing that image reading may contribute for both visual and scientific literacy, it is necessary to emphasize the importance of correct observation while reading facts and images. Silva and Nardi[2] argue that "in science, we collect data through observation; in art we draw through observing. If observation is important, then we need to improve the way we look at things". In the case of the arts, interpretation from an observation is also indispensable since, Panofsky[3] considered that images constitute a culture, that is, in addition to their historical value, they carry with them traits that express thoughts from different eras. As they understand art, they enter this culture, which means that it becomes necessary to improve the way we see things, since as we are exposed to countless images, we end up failing to make valuable observations. In this sense, it is necessary to develop skills to interpret and reinterpret images.[2]

Image reading and works of art: the cultural role for meaningful learning

The information mentioned in the last section concerning the process of reading images is compatible with the development of meaningful Learning. Meaningful learning is a theory developed by David Paul Ausubel, in which this term is used to describe a form of learning characterized as: "[...] in which ideas expressed symbolically interact in a substantive and non-arbitrary way against what the apprentice already knows ".[4] For the process of meaningful learning to occur, certain conditions become necessary. Among them, according to Moreira,[5] new knowledge should be based on something already existing in the students' cognitive structure, on something that is part of his/her reality and that is relevant to them. In order to awaken the student's disposition to this form of learning, this brings us to another necessary condition, i.e, the material in which knowledge is presented for learning. This material, which can be the most diversified, must be potentially significant and have a relevant theme for the student.[5]

In this way, the teacher propose images as material to assist the learning process, more specifically, she used the paintings to develop classroom activities. Paintings are only one of the countless ways of expressing oneself through art, but their exhibition is often restricted to certain places, such as museums or art galleries, which do not always allow people to have direct contact with certain art pieces, especially the most antique ones. Therefore, another space that may allow for the mediation of art and the public, is the school. In this way, it is possible to see that as a result of the image reading of the art work, students may become better prepared to face the world, as they may be able to understand different languages, different cultures and specially, they may be faced with the opportunity to develop competence to establish sociocultural relations. These aspects are fundamental because culture has a straight connection with social life, and its development and understanding is a differential as we refer to social action. In Hall's[6] conception of social action, when significant, it constitutes a system of meanings that human beings used in order to organize, code and regulate human conduct. In other words, culture would be the key to changing reality. This author also states that culture has assumed a role of unequaled importance with regard to the structure and organization of late modern society [...]".[6]

At school, it is extremely important to develop pedagogical practices or provide objects that allow students to learn in a rather critical way, i.e., practices that aims at recognizing the plurality of cultures in order to provide an understanding of the connections between them, so that one can then expand their cultural horizons.[7] In relation to the paitings themselves, some artists were concerned with

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working with the arts and science, placing scientific content in their works, representing, for example, experiments and portraying natural phenomena. Joseph Wright was one of the artists who tried to do that. Therefore, developing a practice of image reading and aesthetic appreciation, involving the paintings of this artist, may contribute to the teaching of science and arts.

Considering the other necessary condition for meaningful learning, i.e., material's theme, in order to explore even further on this issue, generating themes were used together with the paintings. The generating themes according to Tozoni-Reis[8] is a Freirian methodological strategy in which a theme is extracted from the students' real life practice, from a problem experienced, therefore, it emerges from the popular and enables a process of awareness of one's own reality. In Freire's conception (1987, p.53) the generating themes are "[...] because, whatever the nature of the understanding of an action they have trigged, it contains in itself the possibility of unfolding into so many other themes that, in turn, it may provoke new tasks that will have to be accomplished ". In the process of searching and choosing a meaningful theme, it is imperative that the teacher be allowed to problematize it.[9]

Considering Freires conception, and based on the four works by Joseph Wright: Cave, near Naples; The Cave, morning; The Cave, night and A Cave in the Gulf of Salerno, with the figure of Julia banished from Rome", and also based on the students' reality, the thematic 'caves' was chosen to carry out the interdisciplinary science and arts study in order to promote scientific and visualliteracy. This theme was chosen because students at social and economic risk cannot afford to visit such environments nor can they afford to visit museums and art galleries. By using the "caves" as a theme for the class activities, the teacher expected to make the classroom playful and pleasurable by bringing the cave environment to the classroom. It allows the student to experience the dynamics of the place and its living organisms, which may provide interactive learning and the development of systemic thinking.[10]

Also considering the use of these spaces in school, Souza-Silva, Ferreira, Damasceno[11] argue that byco-relating these educational practices to these spaces makes the school an important space and means for the dissemination of the caves to the population. At the same time, these environments characterized as multidisciplinary, may offer practical possibilities for teaching. Mainly for the discipline of sciences, that in this process, may be facilitated through the curiosity that these environments may trigger in the students. As it is a differentiated environment, due to the experiences it may provide, the contact with nature and the innumerable biotic and abiotic forms that the caves offer, it provides in numerable possibilities for the development of various pedagogical activities. These activities in line with the contents worked on in the classroom may help students' personal development and the teachers' professional growth, as well as provide a new way to look at the cave environment.[12] Ferreira, Gomes and Silva[13] also argue that by preparing materials and carrying out teaching practices, they collaborate to publicize the functioning and importance of caves. It may also contribute to develop critical environmental awareness, and to raise awareness in relation to the sustainable use and the preservation of these spaces. By understanding the dynamics of the environment when in contact with it, the student will no longer see the organisms acting individually and they will start to perceive the interrelation between them, the established relationships and the way they impact the environment in which they live. Although the caves offer many possibilities for teaching different subjects such as science, educational practices involving these environments are still scarce. In Brum and Da Silva[10] view, with regard to teaching, what can be noticed is that the approaches to teaching are still quite traditional and for this reason, it is necessary to reinforce the idea of making teaching broader using spaces such as the caves, for example, seeking to value these unique environments endowed with natural wealth to promote scientific education.

Paraná coast and the grotto of the enchanted – a teaching possibility

Paraná is a state located in the southern region of Brazil, occupying an area of 199,880km² equivalent to 2.3% of the country's total area. The formation of the State took place together with the land formation, resulting in a region that shows in the composition of its reliefs the presence of plateaus to the west and east; depression in the central region and low in the coastal region.[14] It is located both in the zone called equatorial and in the temperate zone. Parana State has a variety of physical and natural aspects, ranging from its relief to its varied climates, which also guarantees its rich vegetation. The state is bathed by the Atlantic Ocean and comprises 399 municipalities. Among the main tourist and cultural spots there is the coastline, about 6,000km² in length, and despite being small compared to other coastal areas in Brazil, it has 7 municipalities with several attractions for visitors, among them are beaches, water sports, and the fishing activities. There are also the main ecological reserves with rare species both in their flora and fauna.[15] Amongst the favorite locations for most visitors is the Ilha do Mel, ranked as an Ecological Station since 1982, it is part of the Paranagua Bay, which is currently managed by the Environmental Institute of Paraná (IAP) due to its ecosystem composed of restinga and Atlantic forest.

According to Paranaguá City Hall, Ilha do Mel is divided into 4 main beaches: Encantadas, Farol, Fortaleza and Nova Brasília, with a total area of 2700 hectares, but only 200 hectares are allowed to be inhabited, the remainder is ecological reserve listed by the Historical and Artistic Heritage of Paranasince 1975. For its beauty and mainly for its ecological diversity, Ilha do Mel can be a valuable place for teaching and learning to take place. Most of the contents of the disciplines related to the study of science in Brazil focus or find their complement in subjects involving coastal regions, for example, Physics in relation to the tides, Chemistry in the formation of rocks and Biology for teaching the fauna and flora. However, learning these subjects may be frequently based on a memorized, rote learning process for students, who may not know in practice how the dynamics function in these places in real life. Therefore, taking these places to the classroom tends to bring many benefits for the learning process and for the environment. This means that by including coastal regions, more specifically Ilha do Mel, in the classroom approach to teaching science, the coastal region becomes more than only a valued touristic place; it becomes a space for dissemination of science.

Therefore, this whole process leads to the valorization of scientific education, after all, when looking for the solution to the problems imposed during the problematization, or to disseminate the information obtained, students come into contact with the community. Cascais and Terán[16] state that the moment a student takes science out of the classroom, he tends to take sciencific knowledge to those who do not attend the classes. Thus, science is not restricted to the classrooms, thus it initiates a process that involves the transmission and exchange of knowledge, which can assist in learning the concepts worked in the classroom. Considering the problematization and

the work developed involving natural spaces, it is known that karst environments can collaborate for the teaching/learning process and for the personal and social development of students. In relation to Ilha do Mel, more specifically to the Vila das Encantadas, we have the 'Gruta das Encantadas', where geological formations may be found, unique fauna and flora found throughout the state, so it is essential to study and preserve it. Generating themes when approached to cover natural spaces may provide even more benefits aside from knowledge, as it may bring about change in relation to social behavior. For the coast of Paraná, especially for the Gruta das Encantadas, this becomes essential because, according to Cumin et al.[17]

We can say that our coast presents serious paradoxes. It has a great natural wealth in terms of ecosystems and biodiversity, and most of its territory are under different conservation regimes, but this has not prevented the generation of important environmental problems resulting from the forms of occupation and use, and inefficient forms of management.

We know that not all the problems that affect the coast of Paraná can be solved, but developing a culture aimed at environmental preservation through the teaching of science in these spaces is important and valid. When studying these places in-depth, the use of these spaces may be better preserved considering that predatory tourism and the flow of people is the main economic activity developed at Ilha do Mel.

However, in order to achieve significant levels of preservation of these spaces, the work should begin in school, which, according to Andreoli and Campos,[18] functions as a living laboratory for the creation and adoption of teaching-learning methodologies of a participatory character and that contemplates not only the students but also the bases of the community. From this point of view, we reaffirm that problematizing these places can meet the current educational needs of scientific and environmental literacy and also the needs of visual literacy through the historicity and beauty that the in-depth study of this region may provide.

Materials and method

In order to develop this study, this research was divided into 4 stages: The first one consisted of choosing the canvases and images of the Gruta das Encantadas and also identifying each one. For this moment, 4 canvases were chosen that represent the image of a cave, painted at different times of the day by the painter Joseph Wright and also 3photos taken from the 'Gruta das Encantadas' at three times of the day (Figures 1&2).

Figure 1 From left to right: Joseph Wright de Derby; Cavenear Naples; ç. 1774; 101.6 x 127 cm; oiloncanvas; Yale Center for British Art, Florence. United States; Joseph Wright of Derby; The Cave, morning; ç. 1774; 101.6 x 127 cm; oiloncanvas; Smith College, Northampton Museum of Art, Massachusett. United States; Joseph Wright of Derby; The Cave, night; ç. 1774; 101.6 x 127 cm; oiloncanvas; Yale Center for British Art, Florence. United States; Joseph Wright of Derby A cave in the Gulf of Salernum, with the figure of Julia banished from Rome.c. 1780; 101.6 x 127 cm; oiloncanvas; Yale Center for British Art, Florence. United States.

Sources: From left to right: Yale Center For British Art; Wikimedia Commons; Yale Center For British Art; Yale Center For British Art.

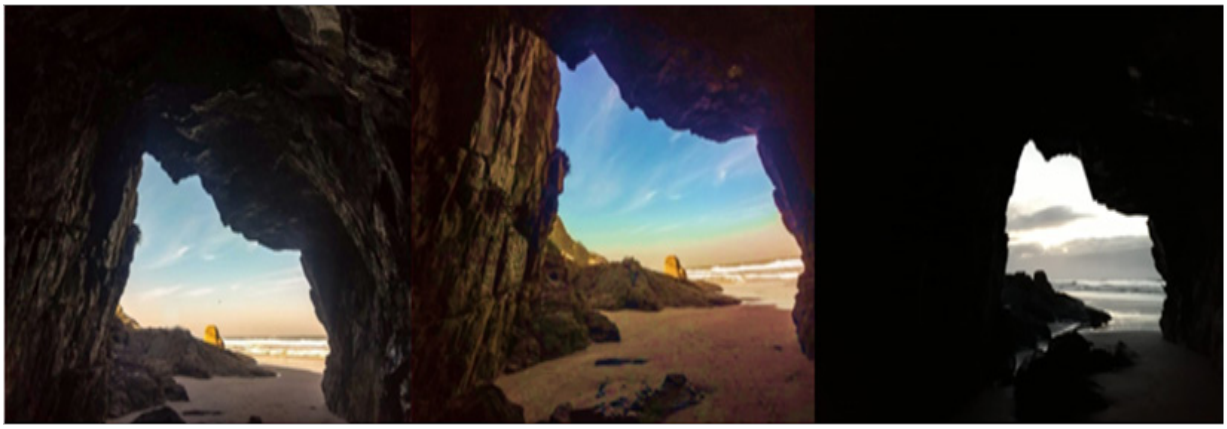

Figure 2 From left to right: Photograph of Gruta das Encantadas in themorning; Afternoon photograph of Gruta das Encantadas; Photograph of Gruta das Encantadas, night.

Source: Own authorship.

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The second stage was characterized by the choice of contents that were worked on in theclassroom in a didacticsequence. The contents were selected according to the possibilities of fered through the observation and identification of the art works in step 1and their relationship with the Gruta das Encantadas. As the contents were all selected in the previous step, the third step is marked by the application of the did actic sequence. The did actic sequence developed is geared especially to interrelate science toWright's art work and the photos of Gruta das Encantadas, in order to provide scientific knowledge to research participants.

As for the third stage, the teacher chose to use the didactic-pedagogical dynamics of Demétrio Delizoicov and José André Peres Angotti[19] called "three pedagogicalmoments"for the construction of didactic sequences for the development of classes, so that students may acquire scientific knowledgeand maybe able to reinterpret the different situations they maybe faced with.

Furthermore, we use Freire'sproposal, which is the use of generating themes. This proposal of a problematization approach focusedon a theme, ittransposes the Freirian conception of education in the classroom. To better guide teachers in this process, it is divided into: initial problematization, organization of knowledge and application of knowledge.[20]

The first momentis characterized by the initial problematization, questions are elaborated based onfacts and real situations that students observe in their daily lives and that may have a connection with the theme.[19] In this case, questions related to Joseph Wright'spaintings and the photos from Grutas das Encantadas were elaborated. In addition to that, students were also familiarizing with the theme, challenging them to form a visual culture.

The second moment consists of the organization of knowledge. In this step, the students were mediated by the teacher, to acquire then ecessary knowledge to understandand solve the problems raised in the previousstep.[20] Finally, in the third pedagogicalmoment, according to the aforementioned authors, as in the previous one, activities were developed in order to systematically address the knowledge that was acquired by the students, not only to answer the questionor solve the initial problem but also to interpret other questions rather than those raised in the first moments.

The last moment of the research, stage 4, students promote apresentation/exhibition of the works and activities developed in the classroom. This step was inserted in the did actic sequence as a final classroom practice, and it was intended to problematize knowledge and enable students to demonstrate what they have learned in the classroom.

Results and discussion

At this point, there por to fthe classroom activities and the discussion about the data collected from the subjects during the development of the stage 4 are presented. The developed sequences were based on the thematic'caves'and also on the three pedagogical moments proposed by Delizoicov and Angotti,i.e., the initial problematization, the organization of knowledge and the application of knowledge.

For the first moment, as proposed in the lesson plan, a comparis on was made between Joseph Wright'swork "A Grottonear Naples" and the photo of the Enchanted Cave in the morning. This was the students' first contact with the images. For this reason, and in view of the observations, we identified what Panofsky understands as the primary level of observation.

During this stage, students did not analyzethe work in depth, failing to consider more complex aesthetic elements. In Arnheim'sconcept[21] "to seemeans to capture some prominent characteristics of objects [...]. The organic development of perception begins with capturing more evident structural aspects." Therefore, it is natural that the students noticed only the most evident elements of the art work, which revealed the need for them to developimage reading skills.

Activities were developed in order to introduce and familiarize students with the theme and to conclude the last pedagogical moment by applying the acquired knowledge in a practical way. The teacher asked students to choose one of the following works: Gustave Courbet's Desperate Man, the Tree Lonely Caspar David Friedrich or A Cave in the Gulfof Salerno by Joseph Wright. After making their choices, students should pay attention to its details, and after that, students were supposed to draw the painting as faithfully as possible. This moment was essential for the study because by asking students to reproduce a painting, it gave them the opportunity to realize how they relate to arts and alsoto perceive the artwork in-depth. According to Marques.[22]

Drawing perceptionis associated with representation. The representation is the first condition for perception to develop. The representation which is the process of conscious acting, enters into dialectics with perception, as anirrational psychological function.

As according to Marques[22] who argues that: "Drawing allows the systematic creation of alternatives. Who ever draws something also builds images. Who ever draws thus stands between there presentation and the experience of that representation". As a result, some studentswere quite faithful in there presentation of the images. This fidelityportrayed in the students' drawing sindicated that whiledrawing they paid much more attention to details as they represented the images than when analyzing them in the initial problematization stage (Figures 3-5).

This moment when students reproduced the pictures was essential for the continuity of the work in the classroom because the act of drawing as according to Marques[22] is considered:

As a fundamental element of creative thinking, drawing enables the organization of the experience of our knowledge. When we draw, we are constantly confronted with new andoldlearning, with new andoldknowledge. Drawing makes it possible, without hierarchy, to organize this information in orderto make visible what is known orinventedat a givenmoment. Idea also means intellectual actor vision. By not attributing the problem too much to the process of integration between the ideaand the real, the intellectual visionis a means from which the subject is equally capable to personificate.

This implies that the moment the students performed there-reading, they observed the artwork unconsciously in more detail and problematized them, developing new meanings for them. In addition, many students took the opportunity to develop the irartistic skills and even discover them, which was very important to develop greater affinity with work sofart and with the discipline.

After the drawings were completed, still within the second pedagogical moment, the teacher carried out the joint reading activity of the Lenda das Encantadas where some questions were raised about the existence of life forms and biodiversity that could be found inside a cave. As the students did not know the Gruta das Encantadas the teacher tried to Familiarize them with the coast of Parana, specially with the region around the Gruta das Encantadas.

Figure 3 a) Screen of the work "Solitary tree"; b) Digitalized image of the reinterpretation of the work made by a student.
Source**:** a) Wikipédia.org; b) Own Authorship.

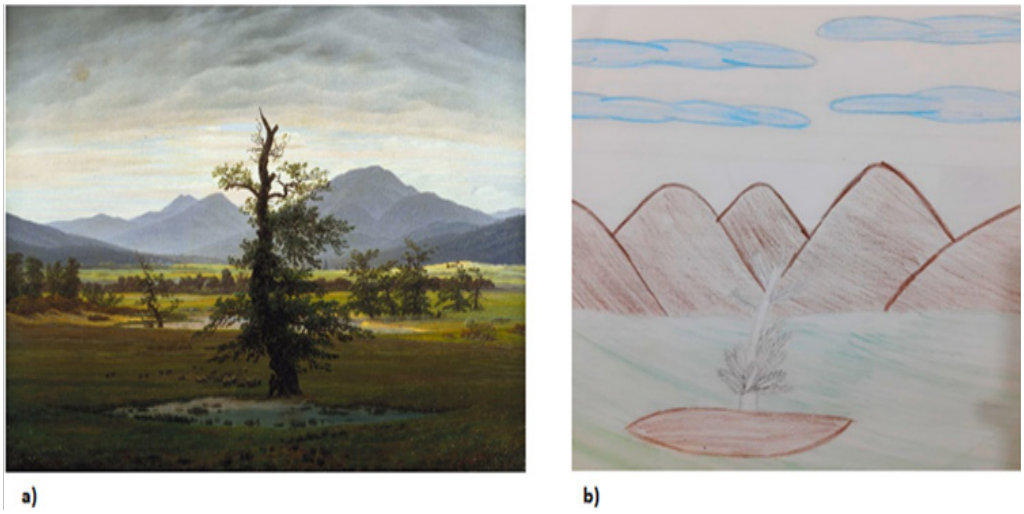

Figure 4 a) Illustration of the "Desperate Man"; b) Digitalized image of re-reading made by the student.
Source: a) Wikipédia.org; b) Own Authorship.

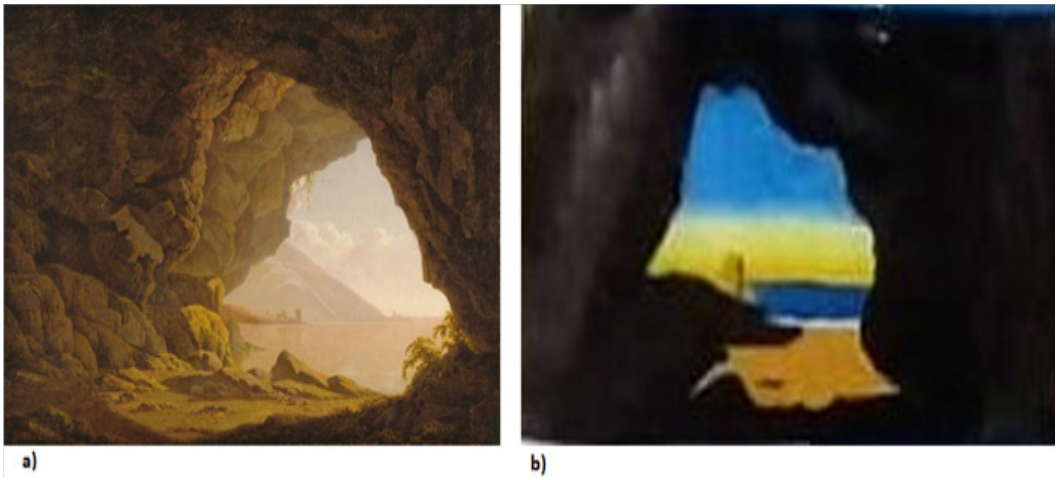

Figure 5 a) Cave near Naples; b) Digitalized image of a re-reading made by a student.
Source: a) Yale Center For British Art; b) Own authorship.

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However, although the biodiversity of the caves was important, students also needed to become familiar with the biodiversity of the environment in which they are inserted, the region in which they live. This process was also extremely important for them. In order for students to perceiveandget in contact with the biodiversity of the place where they spent most of their time, and to further stimulate their critical sense, the teacher continued with the third pedagogical moment'the application of knowledge', where the intention was to take photos and place them on posters to present to the class (Figure 6).

Figure 6 a) Photograph of the João XXIII Institute's biodiversity. b) Photograph of the biodiversity of the João XXIII Institute under the perception of a student. Source: Students participating in the research.

As a result of this application of knowledge, we obtained different images, each revealing the students' perception about the biodiversity. When asked why they chose certain plants and animals to photograph, they revealed that they chose what they thought'was coolestand different to show theircolleagues'.

In this activity, we chose to use photos because in relation to art and science in the understanding of De Moura Carvalho[23] photography can be considered:

A good exercise to ren ewour view of the world is sometimes to change the lenses, to see the same land scapes with different eyes. This means "de naturalizing" the ways of seeing things that we took for granted. We can do this by questioning concepts that have already established in many fields of human experience, thus creating spaces for new learning and for the renewal of some of our life assumptions.

The fact that the students photographed an environment of daily living, in which many spend more time than in their own homes, made them start to observe it in a more detail fullway. In addition, the act ofphoto graphing instigated curiosity about the local biodiversity, causing them to question what they were photo graphing.

The second planned did actic sequence also started with the initial problematization, the students looked at a "grottonear Naplesby Joseph Wright, morning" in relation to the photo of the "Grot to of the Enchanted, morning". Once again in contact with the images, the students asked numerous questions, showing that they were more participative than in the first sequence, a fact that was duet ot hework off amiliarization with the theme and with the place of study that was taught in the first sequence.

In this sequence, the aim was to work on the formation of the caves and the main characteristic of both images in relation to the previous two refered to the'light'. In this sequence, the class content refered to the study of optics (light, photoperiods, color and light propagation), formation of caves (chemical reactions, acid/base concepts), fauna and flora.

In relation to matter spertaining tooptics, class work required detail ful explanation as the student spresented greater difficulty. Regarding the formation of caves, acidand base concepts, there was greater interaction among ststudents due to the fact that in the institution there was already a Project to developa vegetable garden being carried out. So, the students were already familiar with this subject because they made the correction of the soilacidity for their ongoing project during their regular classes. The prompt association of this knowledge with the reality in which they live, indicated that the learning was taking placesince: The essence of the meaning full earning processis, there fore, in the non-arbitraryand substantive relationship of ideas symbolically expressed to some relevant aspect of the subject's knowledge structure, that is, to some concept or proposition that is already significant and suitable to interact with the new information. It is from this interaction that, for the learner, the meaning so fpotentially significant materials emerge (thatis, sufficiently non-arbitrary andrelatable in a non-arbitrary and substantive manner to their cognitivestructure). It is also in this interaction that prior knowledge is modified by the acquisition of new meanings.[24]

After completing the soilacidity activity, students reviewed all contents they had learned up to that point. And they moved onto the moment of applying the knowledge when an experiment was carried

out: Students began to look at "Salt stalactites and stalagmites" to understand how some rock structures are formed inside the caves. In the institution where the practical application of this work took place, there was no science laboratory, sothe experiment was carried out in the classroom and aimed at applying all the knowledge learned throughout the sequence. Experimental practice was extremely important for students and contributed to their scientificliteracy due to. The experiment was one of the most interesting moments of the didactic sequences because the students demonstrated a greatcapacity for team work, organization and cooperation. In addition, this experiment was reproduced by three students participating in there search, in their regular science class. This was considered a very relevant point because, by doing this, students were able to contribute to spread scientific knowledge to their other classmates in their regular classes.

The next didactic sequence started with the comparison of theart work "the cave, night" by Joseph Wright and the photo "the nightat Gruta das Encantadas. In this task, the students were more participative and also demonstrated more knowledge in terms of their perception of the elements of the artwork and of the photo of the Grotto. The focus in this third sequence was'water', which wa spresent inside the cave in the work by Joseph Wright. It served to develop activitieson marine biodiversity and Newton'slaws: universal gravitation; gravity and terrestrial phenomena. In these condpedagogical moment, the teacher used tales and films to approach the theme and trigger students curiosity about the subject in order to work on aspects such as students perception and raise their environmental awareness. These resources were alsoused in order to show the marine environment since the students did not know it.

In relation to what they already knew, both in the problematization and during the process, the teacher asked them about some marine species and about the importance of preserving the fauna and flora in this environment. Although some students did not know thesea, all students knew which species can be found in that environment. Students claimed to have known some species from television programmes, from their science class at school and also from the film showed in class.

This made it eveneasierto move on to the application of knowledge, which in this sequence was broken down into two moments: First, an ocean was madeup from acard board box. The organization for assembling the box was aniniciative that came from the students themselves, which was quite surprising because, again, students required every one to participate and to work as a team. As a result, a beautiful marine environment was produced.

In these cond moment, as they were more familiar with the seaand its biodiversity, students started watching two vídeos on water pollution. In order to bring students closer to this reality, teacher asked students about what they could do to avoid water pollution both at sea and in the region in which they live. The teacher then asked them to form groups and develop work to raise their awareness on thi sissue. The groups discussed the problem and, after that,they developed awareness posters about the disposal of materials, and decomposition time, etc.

The poster and the speeches showed that the students already had knowledge in relation to the environment and recycling, however, it was observed in the initial questionnaire that these aspects were note videnced because the students did not know how to relate this theme to science and arts. For this reason,then extsequences focused on humaninteraction with the environment.

The last sequence started with there ading and problematization of a single image: "The cave of Naples with the figure of Julia banished from Rome" By Joseph Wright. Unlike the first moments, only one painting was used this time for the initial problematization and no photo from the 'Grutas das Encantadas' wasused. In this last sequence, the students described in greater detail what they visualized. Statements such as: "the water is fuller", "nightfall", "the cave isdeeper", "stalactite", "a different perspective", "the sunlightis more inward" were common.

These points revealedthat in terms of imagereading, the did actic sequence was successful. The students, who in the beginning of the practice,described in the first chart only the aesthetic aspects, now, they presenteda more in-depthanalysis of the image. At this moment, students considered the perspective of the image, color composition and lightening.

At this moment, aspects such as the formation of the caves, the entrance area of the cave, thes had owarea and the rock formation such as stalactites were presented in their speeches. In regard to their conception of art developed throughout the sequences, it isnoteworthy that the students started to analyze the art work not only as something to be appreciated in a simpleway, but also as something to be analyzed in depth. According to theNational Curriculum Parameters of Arts[25]: When a student moves to a level of visualization, that makes it possible for him/her to understand the world, he/she must beable to identify, whenever he/she is analyzing animage, the expressive and communicative meaning of the visual forms, as well as he/she must beable to recognize and analyze the different visual forms, in addition to identifying the artistict echniques present in that art work.

Although the students did not use artistic terms to describe the techniques used by the painter, they were able to perceive the mand described them in their own words. This means that during the classes, the students improved their perception and developed the irinterpretivesense of the image. It was evident that the two elements most mentioned during the conversation in the class roomby the students were again'water'and'thehuman figure'. When students were asked whose figure that wa sinside the cave, nobody was able to answer, they only replied that it was the figure of a woman. As students were not clarified who was the woman represented in the painting, and why she was there, they became very curious and attentive. The teacher took advantage of their attention and curiosity to proceed with the questioning and asked them about the impact of human presence in natural environments. Once again the discussions pointed to the issue of garbage. Student H commented: "The problem is that when people visit places, they sometimes throw garbage on the ground." Student M said: "When some one visits these places, they can kill some animals and plants". This moment became important to contextualize the next subject to students, which would be the human impact on nature in cave environments and theimportance of preserving these places.

After these discussions, the teacher answered and explained students' curiosity in relation to whose figure was inside the cave by reading the text entitled"Júlia, Augusto's greatest failure (39 B.C.-14 A.D.). After the reading, social issues were raised such as, for instance, the selling of the artwork to raise funds for there fugeecrisis, and also questions about environmental issues on the impact of the

human actions in the cave environment. Considering the impact of the humanactions in the cave environment and speleotourism, students were asked to remember the caves of the region where they lived and other natural tourist spots in order to discus show these places have been preserved, and during the discussion, the teacher focused on the issue of garbage. This discussion included several suggestions on how they should proceed with the garbage when they visited natural places and how they could manage the garbage at home and at school. For the application of knowledge as the last sequence, it was proposed that students represented in a creative way, everything they hadle arned throughout all the classes. Everyone opted for drawing in the form of re-reading, for example Figure 7:

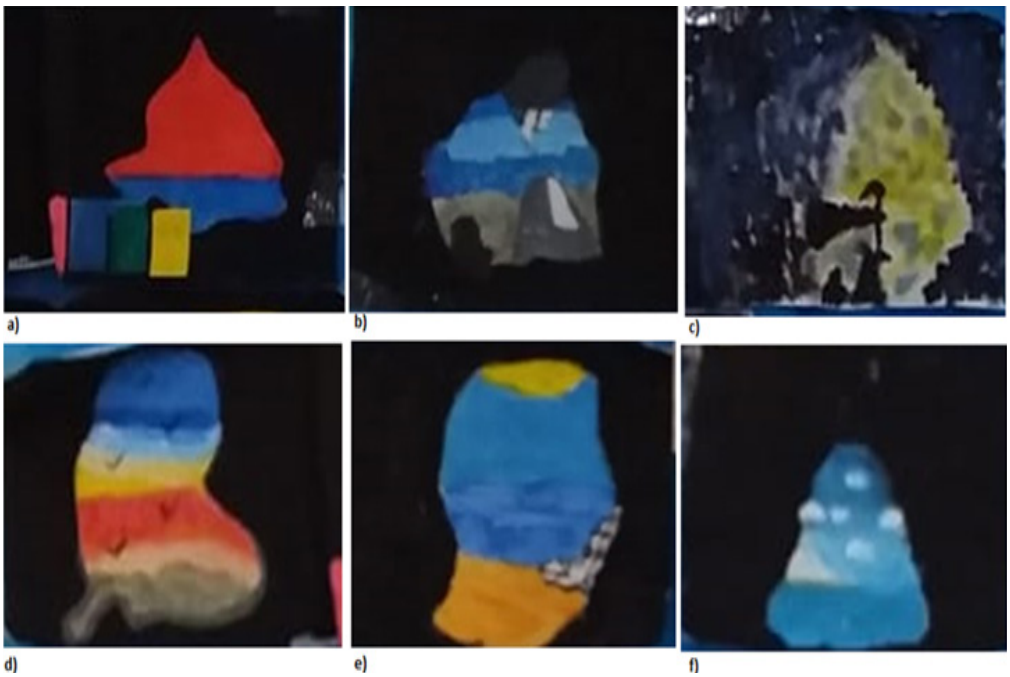

Figure 7 Digitalized images of Joseph Wright's re-reading of "A cave near Naples" developed by the students.
Source: Own Authorship.

Looking at the drawings again, there is evidence of the development of visual perception, scientific literacy and the interelation between science and arts. In addition, there was an improvement in creativity, as student sestablished interelation between all the science contents worked on in the classroom and the details that make upthe drawings.

In drawing (a) we can see that the students ought to emphasize the environmental issue that involves a cave. He reported thathe designed the garbagge dumps inside the Gruta das Encantadas, so that no one would forget the importance of throwing the trash in the correct place. So,we noticed the development of this student's environmental awareness. In drawing (b) the student emphasized the rock formations within the cave, therefore, hesought to draw them in a more evident way. It maybe noticed that he also represented on the roof of the cave entrance a stalactite, which was another content topic discussed in the classroom. In drawing (c) the student, beside susing different painting technique store present the cave, also placed Júlia standing in the center of the image. The student explained that he had placed Julia in the center of the cavetore present the people who enter these spaces, and he also used different colors to demonstrate the lighting inside the cave, just like the original painter. This evinces the student's association of Wright's work with the physics content, more specifically lightening, worked in the classroom. In there-reading (d), the student reported having represented the birds and the sunset seen from the grotto. He also said tha the used these colors because"we studied the different shades in the room that the sunset may display, from yellow tored, all depending on the angle". This speech demonstrated that the student associated the physics content on the incidence of light and reflection angles and tried to portray it in the image. In the last images (e, f), the students mentioned that they used the blue color to represent the sea. When we asked why the sea, they explained that it was what they most liked to study and, there fore, they represented this theme in their re-reading soft he painting. In the last image, it maybe noticed that the student placed these ainside the cave as a means to make reference to the gravity content of the tidal movement.

Analyzing all the paintings made by the students, it was possible to notice that there was no greater difficulty in associating the science contents with the Joseph Wright works of art. It is importante to mentionat this moment that the fact that each of these students has emphasized a specific content to represent the art work does not imply that they have not also learned about theo ther contents taught through out the did actic sequences, but rather it may mean that their associative capacity reflects the theme and the sequence that were most significant to them. Another point that was also evident was the positive development of the aestheticperception that the students presented, according to the National Curriculum Parameters of Arts.[26]

Aesthetic perceptionis the key to artistic communication. In the process of artistic knowledge, which includes aesthetic appreciation, the privileged channel of understanding is the quality of the sensitive experience of perception. Faced with a work of art, perception, intuition, reasoning and imagination skills act both on the artist and

on the viewer. But it is initially through the channel of sensitivity that contactisestablished between the person of the artist and that of the viewer, mediated by the aestheticperception of the work of art. The process of knowledge comes from making significant associations, from the perception of the qualities of lines, textures, colors, sounds, movements, etc.

Conclusion

In peripherical schools and educational institutions in Brazil there are many students immersed in social and economic risks. The task of teachers becomes arduous, as it goes beyond teaching knowledge, to fighting prejudices and social problems such as discrimination due to poverty, discouragement and lack of perspective on behalf the students throughout the learning process, which leads many of these children to drop out of school.

This research was developed in this context where the students are children discredited by society who do not believe in themselves. Their first perceptions was that art only served as anornamenton walls and that it was not possible for them to produce it, much less learn science from it.

Since the beginning of there search we had the great desire to provide class teaching in the scope of science with a differential, quality education to help them construe knowledge that may be valuable for their second cycle of Elementary School. For that, we planned classes using as teaching resource image reading of artworks based on the theme of caves and problematized knowledge in three pedagogical moments. During the development of the work, we highlighted the importance of artistic and scientific knowledge for students and the feasibility of associating arts and sciences for teaching, which is already proposed in the brazilian national curriculum,but doesnot always occur in practice. The didactic sequences involved knowledge from both are as and provided students with an integrated view of knowledge from various areas of study.

This work deal twith problematization of certain themes, where students were challenged to seek the answer to the questionings. The problematization of the activities in the didactic sequences went on different directions, there fore, new content was incorporated according to the educational needs of each class or adapted according to the time table available.

At first the idea was to work with students in the second cycle of elementary school, within the time table of the science discipline. As the opportunity arose, the teacher participant applied there search to a group of students who were assigned to her and who attended, for the most part, recreational activities. Thanks to that, time table was flexible, which was very positive, but on the otherhand, there was resistance on behalf the students to learn science outside their regular class hours.

Another important consideration in relation to the group, is that some of the participants had learning difficulties, which required more detailed work on the part of the teachers explanations and the development of extra activities. But as we had time available all students performed them in the same way, but with in their learning time which made the process more individual and showed positive results.

In relation to structuring the didactic sequence, it was adapted according to the course of the classes, and the problematization approach allowed teachers to have this flexibility in the classroom. The use of art work to teach science, which is not an usual approach to teach, arosecuriosity and questions, making the learning process more interesting to students.

The works of Joseph Wright by themselves already have a scientific character, which also facilitated the approach of different subjects of the science discipline for the students in the different school years. The content was taught to students from different grades using a single sequence, i.e., for the older students, it was a way to restructure knowledge already learned before,whereas for the youngerones, it providedthe bases for learning these contents. So in answering there searh question: "What are the potentialities of a proposal that involves the artwork by Joseph Wright's caves and Gruta das Encantadas for interelating the teaching of sciences?" It is possible to say that considering the work developed with the students in this research, and the methodology used for the elaboration of the didactic sequence, combined with a generating theme, it offers great potential for the teaching of science.

First, students initially did not know that it was possible to teach sciences through arts. In the end, their understanding changed, which is very important for their teaching-learning process, as it opened the door for them to make and perceive associations not only between these two subjects, but also among other subjects in the curriculum.

We know that for many reasons, the teacher cannot always take the students to the place of study, but that should not be na impedement forher/him to bring it into the classroom to be contextualized and become part of the students reality. As the teacher made this contextualization to students in the classroom, as observed in the data, students became more concerned with environmental issues,developeding a sense of social responsibility. In addition, the works by Joseph Wright contributed for the students to acquire cultural knowledge because, with the activities they projected themselves in a different reality from the one which they weere used to.

The students developed cultural and environment knowledge as well as development of artistic and scientific skills during the didactic sequences. The students who at first offered some resistance to learning because they were impeded to attend their regular recreation alactivities, at the end of the research, after realizing that the teaching process was indeed differentiated, they performed better than the expected results.

We also observed through out the sequences that there was progress in the students ability to interact with each other. When students had to interact and exchange experiences and world views with one another in order to perform a certain task, they became more understanding and this generated a greater acceptance of each other.

The students that participated in this study were part of a group of social and economic vulnerability. They were discredited of their abilities, and they claimed to have difficulties to learn. Throughout the research, the perception the students had about themselves changed as they showed new talents and new skills development.

This was mainly because each sequence and respective activities were aimed at working with different competences as required by official documents in education such as the Common National Curriculum Base, National Curriculum Parameters and State Curricular Guidelines. Each student was able to discover their abilities, be it leadership when organizing group tasks, scientific to carry out an experiment, artisan to assemble a naocean in a cardboard box, communicative when presenting the work, photographic and also visual skills.

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The presentations at the end of the didactic sequences contributed to make students very interested and proud of the work they did. This contributed to help self-esteem and consequently helped them to learn better.

Based on all the observations and the results from this research, we conclude that it is extremely valuable to teach classes that involve subjects in the curriculum of elementary school after regular school activities. Although we believe that recreational activities are fundamental for the development of students, they can sharespace with new teaching methodologies. It offers the ideal context for these activities to be developed, which may contribute to strengthen the learning proccess for other subjects in the curriculum.

Finally, we state that activities in this context involve extensive planning and, although its application takes approximately one month, it produced valuable results, not only in relation to the learning/ teaching process but also for the fact that these under priviledged students deserve to experience education of quality.

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None.

Conflicts of interest

The authors declare that there is no conflict of interest.

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