

The Garbage in the Public Space: Sensitization by Science Teaching Using Virtual Reality

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Abstract

This paper recounts the experience of a teaching project, entitled "Virtual Reality in Science Teaching", which aimed to support future science teachers to plan actions addressing the issue of garbage in public spaces from a context, and the use of technologies, with a view to strengthening citizenship and public health. Initially, we contextualize the problem in the garbage in the public spaces from theorists and data that demonstrate the real situation of the world and the city of Manaus. Then it was presented how virtual reality can help educators in the teaching-learning process in the face of the technological environment that is being established in education. Through the use of Google form, we check the development of the students on the subject. According to the students themselves, the tool proposed here has the ability to transport the person to the middle of the problem, causing real awareness and change of attitude.

Keywords: Garbage; Science teaching; Virtual reality.

1. WASTE THEME IN SCIENCE EDUCATION IN FUNDAMENTAL EDUCATION

Population growth and the expansion of urban areas have caused several environmental problems, among which we can mention those related to incorrect waste disposal. Chemical and biological modifications over time due to increased waste change the landscape and damage the environment. Incorrectly disposed garbage also attracts animals, such as flies, mosquitoes, cockroaches, rats, among others, which may be disease carriers [1].

Garbage can be defined in a variety of ways, such as that presented by Garcez and Garcez [2] who consider

garbage to be all solid waste from human activities and even natural processes (dust, dead leaves or branches of plants, carcasses of animals, etc.). Jardim and Wells [1] corroborate the definition by describing garbage as "[...] remains of human activities, considered by the generators as useless, undesirable or disposable". Ferreira [3] describes the term trash as originating from a Latin word (*lix*) meaning gray, linked to the ashes of the stoves. The author also states that garbage is "that which is swept from the house, the garden, the street and is thrown away; rubble. All that is not good and is thrown away. Dirt, dirt, filth. Useless, old, worthless things or things" [3].

Waste can be characterized as domestic, public, commercial, industrial, hospital, organic. Household waste is the waste produced in homes, restaurants, public sectors, commerce in general. Thus the garbage can be composed of food scraps, plastic packaging, paper, glass, etc. [2].

Industrial waste has specific characteristics, because it is produced by industries and depending on the raw materials used can be toxic and therefore, to be deposited with domestic waste needs to undergo specific treatments. Industries are responsible for giving the right destination to the industrial waste produced [2]. Hospital waste is produced in health services and consists of needles, gauze, cotton, coagulated blood, disposable gloves, expired medicines, among others. This is a hazardous waste, because as industrial waste can be harmful to the health of those who have direct contact with it. Thus a specific treatment is required for it and it must be treated or incinerated [2].

Organic waste is all "animal and vegetable waste, that is, all waste originating from a being that has been alive" [2]. In the process of decomposition in the open air it can produce slurry, which causes bad smell and can cause soil and water contamination. Regardless of the type of waste if not disposed of correctly, it can cause environmental problems and increased disease.

According to the United Nations Environment Program, waste production is expected to increase from 1.3 billion tons to 2.2 billion tons by the year 2025. Daily consumption of industrialized products is responsible for the continued garbage production. The production of garbage in cities is such that it is not possible to design a city without considering the problem generated by solid waste, from the generation stage to final disposal [4].

Given this situation, school education can contribute to awareness related to the theme by developing activities that address the waste within the local reality. Garbage, due to its characteristics and daily presence in public and private spaces, can be used pedagogically, provoking or rekindling issues, feelings and arguments leading to discussions of values and lifestyle, urban life and industrial society [5].

Thus, the theme related to garbage needs to be approached at school not only as a distant content from the local reality, but it is necessary to search in scientific knowledge the basis to propose solutions to real problems caused by garbage in public space. These contents can be approached from two of the four thematic axes outlined for science education for the 3rd and 4th cycle in the National Curriculum Parameters for Science Education [6]: Life and Environment and Human and Health. According to The document among the general objectives of teaching natural sciences to elementary school are: - Understand personal, social and environmental health as individual and collective goods that must be promoted by the action of different agents; - Formulate questions, diagnose and propose solutions to real problems from elements of the Natural Sciences, putting into practice concepts, procedures and attitudes developed in school learning [6].

In this sense, the theme related to garbage in elementary school can be approached from a public health study perspective, showing how incorrectly disposed garbage in public spaces can cause diseases such as tetanus, hepatitis A, cholera, worms, among others. From this, it is possible to formulate questions and propose solutions based on the knowledge studied for the local reality related to the garbage problem, seeking to explore issues related to citizenship and the environment.

Approaching the theme related to garbage in this way can contribute to overcome some difficulties for learning and teaching the Natural Sciences in elementary school, such as overcoming a scientific teaching away from the reality of students, because at the same time that they discussing knowledge related to public health, environment and citizenship, they can apply it to the local reality, which can provide meaningful learning. “Through work themes, the teaching and learning process in the area of natural sciences can be developed within socially and culturally relevant contexts that enhance meaningful learning [...]” [6].

At the Common National Curriculum Base we also observe the possibility of approaching the theme related to waste within the local context, because according to the document, one of the competences to be developed through the study of the natural sciences is: **COMPETENCE 7: Act personally and collectively respect, autonomy, responsibility, flexibility, resilience and determination, using the knowledge of the Natural Sciences to make decisions on scientific-technological and socio-environmental issues and on individual and collective health, based on ethical, democratic, sustainable and solidarity** [7].

In the thematic units proposed for the study natural sciences, we found in the 5th grade the object of knowledge Recycling for the thematic unit matter and energy. Addressing this theme aims to develop the ability to “build collective proposals for conscious consumption, proper disposal and expansion of reuse and recycling habits of materials consumed in school / or in daily life” [7].

Thus, we observe in the guiding documents of elementary school the possibility of approaching the problem of waste from the local reality in a transversal way, focusing on content that addresses issues related to public health, citizenship and environment. This can be done as an aid to Information and Communication Technologies (ICT), such as virtual reality using smartphones and Cardboard glasses.

2. VIRTUAL REALITY APPLIED TO TEACHING

Information and Communication Technologies (ICT), especially digital and network technologies, have caused several transformations in Contemporary Society. These transformations can be felt in various fields, such as economics, culture and education. With regard to education, it is essential to use these technologies, as they are already part of the social context of students and they can enhance, if used in an emancipatory perspective, the formation of critical citizens and meaningful learning.

Among the many ICTs that can be used in the school environment we can mention Virtual Reality (VR). This technology can be understood as a tool that provides a three-dimensional environment created by software, and that allows us to be transported to a virtual place without having to move [8].

From this definition it is also possible to see that to use VR requires a machine (computer or smartphone), specific software and virtual reality glasses.

For a long time RV was difficult to access due to its high costs. One of the solutions that made this technology more accessible to the population was the development of the Google Cardboard platform. This

virtual reality platform works primarily from the use of Cardboard glasses, built with inexpensive materials and free downloadable applications.

Several authors have developed teaching projects using VR with the aid of Google Cardboard. One such project is “Virtual Reality and Geography: The Case of Google Cardboard Glasses for Teaching” [9]. The focus of this project was the teaching of geography for children from 6 to 8 years old. For its development, the authors used Cardboard Glasses, smartphone, Youtube 360 software, Google StreetView and Google Earth. The authors used VR to virtually bring children to the most diverse places in the world (Egypt, New York, Europe, etc.) and to show the particular geographic features of each space, all without leaving the classroom. The author concluded that VR can be an excellent tool for teaching geography.

Another teaching project that used VR as an aid in the teaching-learning process was entitled "Digital Anatomy: A Virtual Environment Supporting the Teaching - Learning Process", which aimed to create a virtual game to better approach the system in the anatomy discipline. human health courses, and apply it using smartphones and Google Cardboard glasses. The author points out that the content approached in the project, in general, is taught only using the textbook, using only the memorization of the content. From the experience of the project, the author concludes that the process of teaching and learning using VR was more significant, as students had the opportunity to learn immersively and interactively the contents of the human anatomy, observing the urinary system internally and detecting possible anomalies, rather than just seeing the pictures printed in the textbook [10].

The two projects presented in this section demonstrate that VR allows the construction of learning based on immersion and interaction, allowing the exploration of the proposed contents through a three-dimensional investigation, which makes it more real for the student. In addition, VR can be a solution to the displacement difficulties we encounter when proposing activities that require visits to places far from the school. This technology can also increase the interaction between theory and practice, as the student is able to build their own 3D images. According to Carvalho [11], other advantages of using VR in the teaching-learning process are:

- Promotes student motivation;
- Requires and promotes greater interactivity, ie encourages active rather than passive participation;
- Provides new ways of displaying information, and thus allows to illustrate more precisely some features, processes etc.;
- Allows better understanding of study objects due to the possibility of multiple views of an object within the environment;
- Enables you to view non-existent or hard-to-reach places;
- Does not restrict learning to the regular class period, enabling educational activities through the internet;

Interaction can be one of the ways for the formation of critical citizens and meaningful learning, as it encourages the student to leave the passive role of learning, thus becoming an active subject of this process. Thus, it is understood that VR can enhance this type of learning.

3. PROJECT IN ACTION: FROM PLANNING TO RESULTS




Based on the theoretical assumptions presented in the previous sections, the Project “Virtual Reality in Science Teaching” sought ways to approach the theme related to waste in science teaching using virtual reality and other technologies. In this section we present how the project was planned, its execution and the results.

3.1 Planning the Project

The first step for project planning was the choice of the theme to be developed. Due to the problem of garbage in public spaces in the city of Manaus, we sought didactic proposals that were contextualized with the reality of the students, concluding that this could be the theme to be addressed in the project. After a study on the issues related to garbage in the city of Manaus, the project anchor was outlined: What are the effects of garbage on public spaces? The driving questions were: What types of trash are found in public spaces? What causes the proliferation of waste in public spaces? What are the consequences of garbage on the quality of life of people who live or work in these spaces?

From the choice of theme, we defined the technology that could be used in order to explore the context in a meaningful way. Based on the technological experience of some of the group's components and the possibilities of immersion and interaction, the technology chosen was RV using Google Cardboard. Although VR was the main technology chosen for the execution of the project, we outlined that we would present to the students other technologies that could be used by the students during the activities, as we can see in Table 1.

Table 1: Technologies Presented to Students

Application / Tool	Description	Available in:
<i>Google Street View</i>	Google app that allows you to view 360° photos from different places and also make it possible to create 360° photos	
<i>Camera Cardboard</i>	Application to capture and share photos with virtual reality (RV). RV photos let you hear sounds and see the scenery in all directions and in 3D.	
<i>Google Cardboard</i>	Cardboard frame glasses developed by Google and cost-effective, this device works with virtual reality and enables fantastic experiences.	

<i>Khan Academy</i>	With a mission to provide high quality education for anyone, Khan Academy is an NGO that offers a free collection of over 3,800 videos in math, medicine and health, economics and finance, physics, chemistry, biology, computer science, among other matters.	
<i>Geenkie games</i>	It is a platform with several questions of the enemy that allows the student to train their knowledge, and the platform also allows teachers, schools and departments of education to have access to the performance of their students and can understand the main difficulties of students.	
<i>Phet</i>	It is a collection of over 100 interactive simulations for science teaching and learning.	
<i>Scratch</i>	Scratch is software that uses logic blocks, sound and image items to develop your own interactive stories, games and animations, and share your creations online.	
<i>Google For education</i>	It has several useful options for both students, teachers and education professionals. It offers several educational tools that allow students and teachers an alternative to study and to carry out school projects.	
<i>YouTube Edu</i>	Free and quality educational content in Portuguese. YouTube Edu is a partnership of the Lemann Foundation and Google that brings together the best educational content on YouTube. Curated by the Lemann Foundation, the channel works as a filter, providing very high quality classes organized, for example, by high school subjects.	

Source: The Authors, 2019.

Therefore, we think of the project as a short course with a 20-hour workload for future science teachers. The planning of the course was accomplished through the elaboration of an activity script for the students, which presented the orientations of the development of the actions and their schedule, from the beginning to the conclusion. During the planning phase we built a site for the project using the Google Site feature. On the project website (Figure 1) students could know the project objectives, have access to the learning script and the schedule.

Figure 1: QR Code to access the project website



Source: The Authors, 2019.

In this phase, we also built, using the Google Form, the registration form and a questionnaire to diagnose students' previous knowledge about technologies and their use in teaching practices, which were added on the project website. On the site were also provided specific tabs for later to be posted the results of the project and photos of its implementation.

The course activities were planned and distributed for six days, as shown in Table 2.

Table 2: Distribution of Course Activities

ACTIVITIES	DELIVERIES
<ul style="list-style-type: none"> • Project presentation • Team definition • Project website presentation • Completing the application form • Take the survey on Google Forms • Presentation of the learning script 	Application form and questionnaire submission
<ul style="list-style-type: none"> • Definition of what thematic aspect each group will work on and possible technologies that will be used in the production of the didactic material; • Definition of the public space that will be used as the basis for the production of the didactic material 	Choose the technologies that will be used, the theme, and the public space
<ul style="list-style-type: none"> • Collect Information from Selected Space - (Location Characteristics, Trash Type, Location, Historical Context) • Start the production of teaching material (photos, videos, among others) 	-
<ul style="list-style-type: none"> • Presentation of the public space and the theme that each group will work on and the possible technologies that will be used in the production of the didactic material. • Preparation of the planning outline 	Delivery of teaching material (photos, videos, among others)
<ul style="list-style-type: none"> • Continuation of preparation of planning outline 	Planning Delivery
<ul style="list-style-type: none"> • Socialization of groups 	-

At the planning stage, it was also necessary to acquire the material to build Cardboard glasses. The materials purchased were: cardboard pizza box, biconvex lens, ferrite magnet, glue, scissors and stylus. Eyeglass mounting guidelines can be found in the video at the QR Code address in figure 2.

Figure 2: QR Code for Cardboard Eyeglass Mounting Guidance Video Access



Source: The Authors, 2019.

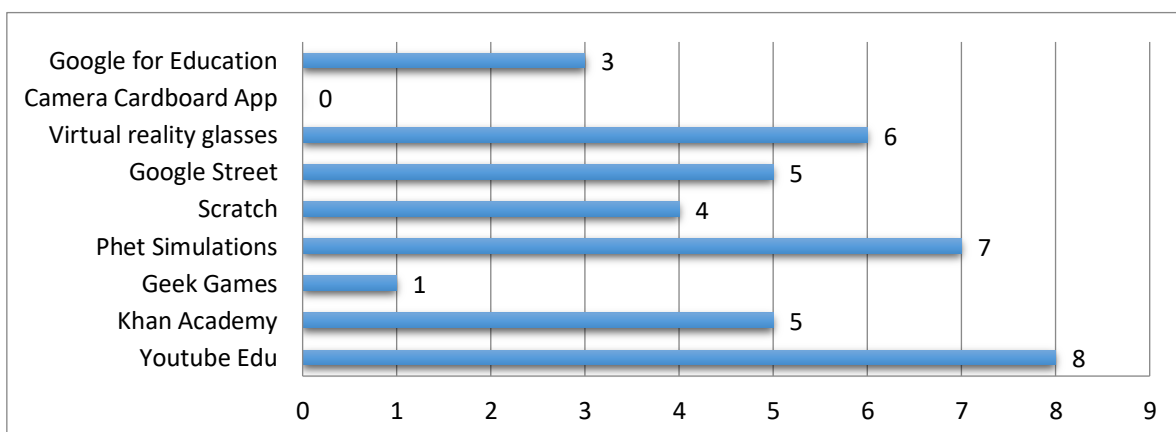
In the developed activities, we use multimedia projector, computers with internet access, specific software / applications for the proposed activities, virtual reality glasses (Cardboard) and smartphones. In the next section we will introduce how this planning has been put into practice with the participants.

3.2 Execution

The course was increased in the computer lab on the premises of the Federal Institute of Education, Science and Technology of Amazonas (IFAM), Campus Manaus Center (CMC), we defined a classroom workload of 20 (twenty) hours, distributed over six days in the morning. This course advocated the construction of a teaching plan in the form of a project appropriate to the context of the Science discipline, addressing the theme: garbage in public spaces in the city of Manaus in elementary school science classes using digital technologies, with a view to strengthening citizenship and public health, supporting the elaborate teaching planning, considering the science subject and discipline.

The participants of the course were 10 students, 10 Supervised Internship Students in Biological Sciences, Chemistry and Physics at IFAM / CMC. Participants were 20 years old on average and most were women. Initially, the participating students answered a questionnaire in order to diagnose their knowledge regarding technologies that could be used in science education. The students' answers showed that although they did not use the technological resources presented in the questionnaire, many knew them, as we can see in Graph

Graphic 1: Technologies known to the students participating in the course



Source: Field Research, 2019.

After knowing what knowledge they had about technology, we began the execution of the next steps, which for didactic purposes, we will present in this section through five steps.

The first stage aimed to: i) seek information about the public spaces in question (Name, origin, contribution to the city of Manaus); ii) identify the problems related to garbage around the chosen public spaces; and iii) form working groups for the development of activities. To achieve these goals we have developed the following activities:

- Presentation of the project by the responsible teachers and the project website;
- Students watched the video “Manaus among the worst cities with garbage accumulation”¹;
- After the students watched the video, it was exposed to them how the theme related to garbage is presented in the 3rd and 4th cycle Science NCPs and in the BNCC Document;
- Students watched the videos “Virtual Reality Transforms the Experience of Child Vaccination”² and “Google Expeditions for the UK: Take Your Students Around the World in VR”³. To learn about some of the characteristics of VR.

- Students formed groups to perform the work and choose which public space to use as a basis for building the planning and production of photos in 360 degrees. The students were divided into two groups, each containing 5 students, to define the aspects of the proposed theme that they would explore and which possible technological products would be used.

Team 1 chose the theme garbage and citizenship and decided to work in the space located at the Manaus Moderna Fair, specifically in the fruit pavilions. The Modern Manaus Fair is located in the city center of Manaus, and make up a complex with 6 pavilions divided into 927 boxes. Today this fair is responsible for supplying the city with regional, national and international products. Among the marketed products, we can find meat, fish, fruits, legumes, vegetables and non-perishable foods such as flour, rice etc.

Team 2 chose the theme garbage and environmental education, and decided to work in the space located in the vicinity of the Federal Institute of Amazonas - IFAM CMC. The Institute is located in the Center of Manaus, in an area surrounded by residential houses, with more than 100 years of existence in Manaus. IFAM currently offers integrated high school to the technician, subsequent technician, undergraduate and graduate. Observing the chosen place, the students realized that the residents of the vicinity do not care about the disposal of garbage, discarding them around the Institute.

The second stage aimed to “know and explore the possible technologies to work on the theme related to waste in public spaces in the city of Manaus”. For this the teachers:

- Explained the possibilities of virtual reality glasses, how to assemble it using low cost materials and demonstrate how to use Cardboard and Street View applications. Then the students experienced how virtual reality glasses work (Figure 3).
- Demonstrated other possibilities of technologies to address the theme: Youtube Edu; Khan Academy; Geek Games; Phet Simulations in Biology and Scrath.
- They asked the teams to define the aspect of the proposed theme they would explore and what

¹ Available in: <https://www.youtube.com/watch?v=gjIyJKnLqWM>.

² Available in: <https://www.youtube.com/watch?v=QG17qwl-j8Y>.

³ Available in: <https://www.youtube.com/watch?v=n29VQwW-03o>.

possible technological resources would be used.

Figure 3: Student knowing about cardboard glasses made for virtual reality



Source: Field Research, 2019.

In the third stage the students went to the field with the purpose of building didactic materials to work the theme reacted to the garbage in the public spaces of the city of Manaus. The students took 360° photos of the chosen spaces that represented the garbage situation in them. In this activity the students also recognized and described the situations of the chosen public spaces.

The fourth stage aimed to “Build a planning of actions that could be implemented in the classroom to address the theme of waste in public spaces in the city of Manaus, using the didactic materials developed in step 3 and the Constructive Alignment approach. To achieve this objective, the following activities were performed:

- Teachers explained how to make a plan;
- Teachers presented a basic template for planning construction;
- In the groups the students started the elaboration of the planning with the help of the teachers.

At the conclusion stage of the workshop the students presented the elaborate plans and the photos taken with the indicated applications.

3.3 The results

At the end of the course the two teams presented the elaborate plans. Below we will describe the characterization that each team made of the garbage in the chosen public space, the 360° photos and the teaching planning built.

Team 1: Characterization of garbage and the elaboration of 360° photos. Organic waste was found at specific points of the Manaus Moderna fair. Fruit scraps like banana, watermelon, papaya, etc. As already explained, in the process of decomposition in the open air the garbage can produce slurry, which causes bad smell and can cause soil and water contamination. After characterizing the garbage, the students produced 360° photos using their mobile phone and the street view app, as we can see in Figure 4.

Figure 4: Photo of the Manaus Moderna fair, fruit sector.



Source: Field Research, 2019.

Team Teaching Planning 1. In the planning the team proposed the activities in project format lasting eight classes. In the first two classes, the team planned to present the project to the students and discuss in a dialogical manner the scientific content necessary for the development of the project, which involves the concept, types, treatments, destination and current reality of garbage in the world and in the city. Manaus. In the third class, the team suggested a class aimed at making Cardboard 3D reality glasses together with students so that students could understand virtual reality using low-cost glasses and Google Street View apps. and Cardboard Camera. The objective proposed for the next two classes proposed by the group was to research, analyze and integrate into the place of coexistence, seeking images of the correct and incorrect disposal of waste in the internal and external school space. In this class, the teachers left the students free to take pictures of the way garbage is disposed of in and around the school. Then, the teachers proposed that the students create a presentation with the reality encountered during the activity of photography and from that reality propose solutions for improving the treatment of waste in the study area. The culminating activity of the project built by team 1 would be to raise awareness among the external and internal community about waste treatment. For this the students would present the other classes and the external community around the school the proposals for improving the treatment of waste in the living area and around with community participation.

Team 2: Characterization of garbage and the elaboration of 360° photos. Household-type waste has been found in certain locations around IFAM. The students realized that the houses surrounding the Institute do not have a suitable place to throw their waste, so the garbage will end up in the walls of IFAM. The team also took 360° photos (Figure 05) to use with Googleborad and work on awareness.

Figure 5: Photo 360° Federal Institute of Amazonas showing some points where the garbage is dumped by the residents of the surroundings.



Source: Field Research, 2019.

Team Teaching Planning 2. Students proposed three 50-minute classes to work in science classes. This team did not propose a project, only classes that dealt with the theme related to garbage in public spaces and environmental education. The team's proposal was to ask students to record for 24 hours all garbage produced, from candy wrapper to pet bottle. In the first class students would then be led to analyze how much garbage they produced in the last 24 hours. This would be the initial approach to the class that would address the local reality of waste and the amount of waste produced in the world. The teachers would then show the students using the Cardboard glasses the photographs of the reality of the surrounding school, in this case the IFAM. The second class would aim to address the 3 Rs (reuse, recycle and reduce), so the students planned to use videos from Youtube Edu. After presenting the scientific knowledge related to the 3 Rs, the teachers proposed that students classify the waste in the list produced in the previous class. This activity aims to demonstrate that much of the things we discard can be part of the selective collective and be reused, recycled and reduced. The last proposal in team planning 2 aimed to start a campaign to raise awareness of the importance of proper waste disposal at school and at home.

4. OUR CONSIDERATIONS

During the realization of the project in short course format we observed an ease on the part of the participants to use the technologies. While most participants did not know VR using Google Cardboard, their familiarity with smartphones made learning easier. This highlighted how technologies can be used effectively for the development of teaching projects, because ICTs are part of students' daily life and they are interested in activities that involve them.

When we presented the planning template in a constructive alignment approach, a good part of the students said they already knew this form of planning. However, in the elaboration of the planning we observed many difficulties, especially in thinking about planning in project format. Only one team was able to approach the theme in a project format, which makes evident the difficulties that we teachers still have in thinking about learning by projects and transcending a content teaching focused only on memorization. This pointed out to us, who designed the project, the need for a new application of the project to think of a more emphatic approach to the importance of project learning.

Participants had no difficulty in addressing the issue in science education, as noted in the final lectures of the teams, this has been a prominent topic in the media. However, we observed difficulties in exploring the theme using ICT. We provided participants with several technology options, but as we can see in the results section, Team 1 used VR only and Team 2 used RV and some Youtube Edu video. This shows that although we use technology often in our daily lives, it is not a common practice to use it in teaching practices.

Finally, during the application of the project we observed that addressing the theme of waste in science education is a matter of citizenship, environmental education and public health, although no group has addressed the theme in this last aspect. The approach of this theme becomes more significant when we start with a local analysis with the help of technologies.

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