SciELO Preprints

Publication status: This preprint has been published elsewhere.
DOI of the published preprint: https://doi.org/10.11606/issn.2179-0892.geousp.2026.231834.en

Learning about sustainable cities through urban sanitation simulation with the game Cities Skylines

Solange Francieli Vieira, Marquiana de Freitas Vilas Boas Gomes

https://doi.org/10.1590/SciELOPreprints.15991

Submitted on: 2026-04-29
Posted on: 2026-04-30 (version 1)
(YYYY-MM-DD)

SciELO Preprints - This document is a preprint and its current status is available at: https://doi.org/10.1590/SciELOPreprints.15991

Article

Learning about sustainable cities through urban sanitation simulation with the game Cities Skylines

Aprendizagem de cidade sustentável por meio da simulação do saneamento básico urbano com o jogo Cities Skylines

Aprendizaje de ciudad sostenible a través de la simulación del saneamiento básico urbano con el juego Cities Skylines

Solange Francieli Vieira

Universidade Estadual do Centro-Oeste (UNICENTRO). Guarapuava, PR, Brasil.

Instituto Federal Catarinense. Blumenau, SC, Brasil.

https://orcid.org/0000-0002-6254-6709

solange.vieira@ifc.edu.br

Marquiana de Freitas Vilas Boas Gomes

Universidade Estadual do Centro-Oeste (UNICENTRO). Guarapuava, PR, Brasil.

https://orcid.org/0000-0002-4658-3569

marquiana@unicentro.br

Recebido em: 09-07-2025

Aprovado em: 17-12-2025

Editora do artigo: Amanda Regina Gonçalves

ABSTRACT

This article aims to investigate the learning process of sustainable cities using the digital simulation game Cities Skylines, with a focus on urban sanitation. The educational potential of simulation for Geography lies in its ability to reproduce, manipulate, and visualize aspects of reality in a holistic manner, expressed through geovisualization in the virtual model. Based

SciELO Preprints - This document is a preprint and its current status is available at: https://doi.org/10.1590/SciELOPreprints.15991

on this, the research adopts a qualitative methodology, employing a case study approach with the application of a didactic sequence, systematically recording each stage and analyzing the content of the activities performed by the students. The results reveal an expansion of geographic knowledge through the manipulation of variables related to basic sanitation, as well as the development of geographic thinking through the construction, reflection, and reasoning involved in the management of a sustainable city.
Keywords: Geography learning, sustainable city, digital simulation game, basic sanitation.

RESUMO

Este artigo tem como objetivo verificar o processo de aprendizagem de cidade sustentável com o uso do jogo digital de simulação *Cities Skylines* com o enfoque no saneamento básico urbano.

O potencial educativo da simulação para a Geografia está na possibilidade de reproduzir, manipular e visualizar de forma holística aspectos da realidade, expressos pela geovisualização no modelo virtual. Com base nisso, adotamos nessa pesquisa a metodologia qualitativa, do tipo estudo de caso, com aplicação de sequência didática, com registro sistemático de cada etapa e análise de conteúdo das atividades realizadas pelos alunos. Nos resultados, constatamos a ampliação dos conhecimentos geográficos, por meio da manipulação das variáveis relativas ao saneamento básico, bem como o desenvolvimento do pensamento geográfico por meio da construção, reflexão e raciocínios mobilizados para a gestão de uma cidade sustentável.
Palavras-chaves: aprendizagem de Geografia, cidade sustentável, jogo digital de simulação, saneamento básico.

RESUMEN

Este artículo tiene como objetivo verificar el proceso de aprendizaje de la ciudad sostenible mediante el uso del juego digital de simulación Cities Skylines, con un enfoque en el saneamiento básico urbano. El potencial educativo de la simulación para la Geografía radica en la posibilidad de reproducir, manipular y visualizar de manera holística aspectos de la realidad, expresados a través de la geovisualización en el modelo virtual. Con base en ello, en esta investigación adoptamos una metodología cualitativa, tipo estudio de caso, con la aplicación de una secuencia didáctica, registrando sistemáticamente cada etapa y realizando un análisis de contenido de las actividades realizadas por los estudiantes. En los resultados, constatamos la ampliación de los conocimientos geográficos mediante la manipulación de las variables relativas al saneamiento básico, así como el desarrollo del pensamiento geográfico a través de la construcción, reflexión y razonamientos movilizados para la gestión de una ciudad sostenible.
Palabras clave: aprendizaje de Geografía, ciudad sostenible, juego digital de simulación, saneamiento básico.

SciELO Preprints - This document is a preprint and its current status is available at: https://doi.org/10.1590/SciELOPreprints.15991

INTRODUCTION

Currently, we are experiencing accelerated changes in the means of information, entertainment, communication, product marketing, and access to knowledge. Life in society is permeated by technological means that mediate the relationship of the subject with the world. In the educational field, these artifacts are inserted with the use of cell phones that often "steal away" the attention of students during classes. The challenge is to keep students' attention to the teaching process and, consequently, to generate meaningful learning and, in this sense, reflections on how to ensure their involvement and interest are appropriate.

Geography is a science of the present, which seeks to elucidate the reasons for the locations of phenomena and processes, as well as to allow the understanding of the spatial organization of society, social relations, and the dynamics of the physical environment in an integrated way. Therefore, even though school Geography is not a mirror of academic Geography, its maintenance in the curriculum has an important potential for the formation of subjects who understand the geographical space and develop their citizenship.

Its mastery allows students to understand the reasons why "things" are where they are. This, however, requires learning situations that generate concerns, inquiries, and stimulate reasoning that results in awareness, focused on the development of thought.

In this sense, it is possible to appropriate a set of technologies, including those present in the students' daily lives, such as digital simulation games. These are means of entertainment, but they can be presented as an important didactic resource in basic education, such as the game Cities Skylines. In this article, we present an experience of using this digital game to develop concepts related to urban space, specifically, via the discussion of basic sanitation. This is one of the results of the doctoral research, which sought to explore the potential of this technology in geographic education.

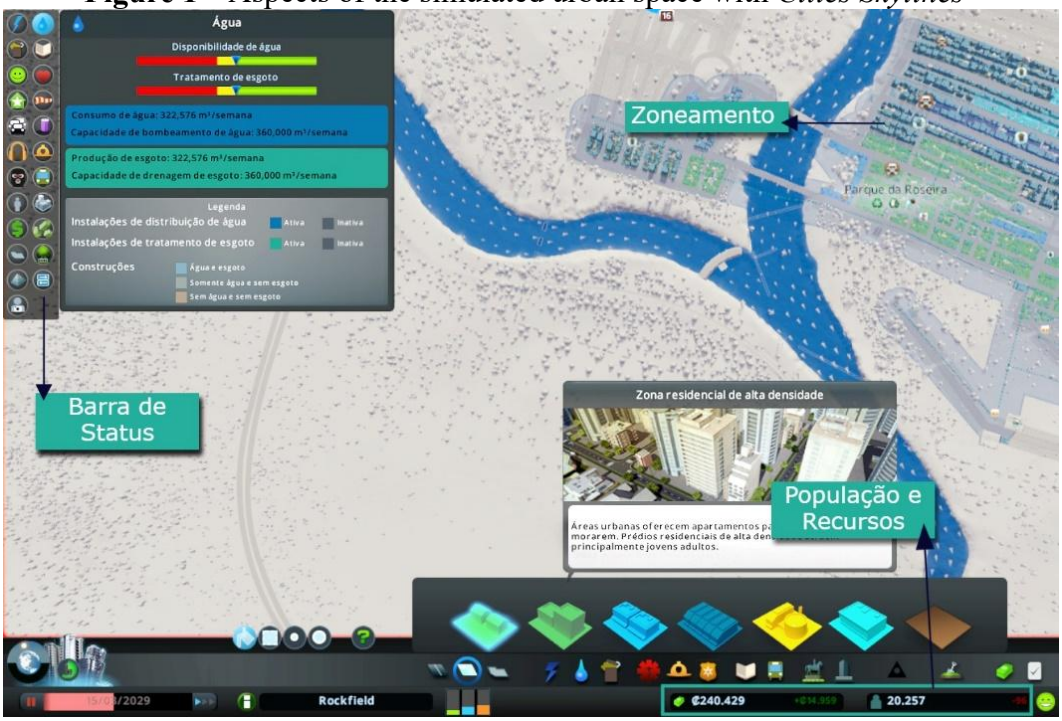
The research was conducted with high school students, through the implementation of a didactic sequence, with some of the results presented in this article. To do this, we divided the text into five topics. In the first three, we contextualize the relationship between the use of the game and the thematic discussions held in geographic education in the application of the didactic sequence. In the fourth topic, we describe the methodological procedures of the research. And, in the fifth and last topic, we detail the results obtained with the use of the game Cities Skylines in the simulation of basic sanitation in urban space.

SciELO Preprints - This document is a preprint and its current status is available at: https://doi.org/10.1590/SciELOPreprints.15991

SUSTAINABLE CITY LEARNING THROUGH SIMULATION GAME CITIES SKYLINES

The digital game Cities Skylines is a game that simulates the construction of a city from scratch. The player is the mayor of this city, and it is up to him to decide how to build it and manage its demands. To do this, the game has several variables that allow you to manipulate and visualize aspects of the urban space, such as the construction of: circulation routes (roads of various types and pedestrian paths); zoning (residential, commercial and industrial); education (from basic to higher); electricity (generation, implementation and distribution); water supply; sewage collection and treatment; solid waste management (incinerators, recycling policies...); green areas (parks, squares, reforestation); health services (clinics, hospitals, crematoriums...) among others (Figure 1).

Figure 1 – Aspects of the simulated urban space with *Cities Skylines*



Source: Cities Skylines – Prepared by the authors.

The absence of basic infrastructure or essential services can affect growth and even lead to the bankruptcy of the city. Therefore, the player needs to be aware of the demands, the problems that arise, the available budget and the objective linked to the type of city he wants

SciELO Preprints - This document is a preprint and its current status is available at: https://doi.org/10.1590/SciELOPreprints.15991

to build (in the sequence carried out in the research, the focus was the sustainable urban space).

The simulation game, by presenting urban space as a scenario, in the form of construction and management, enables the monitoring of the development process of a city, even if in a simplified way. The variables (circulation routes, services, green areas, among others) are gradually incorporated and, with this, the interaction between the elements occurs, so that the urban dynamics emerge in each phase and it is possible to visualize aspects of the urban space present in a concrete city. This movement of spatial arrangement enables the student to perceive change and contributes to the formation of concepts that allow contextualizing and understanding the spatial organization resulting from the choices in the gameplay.

But what specifically is simulation? Marrón-Gaite (2013, p.46, our translation) defines it as "a technique that aims to reproduce the essence of a reality in reality, with the aim of making it easier to capture." For her, it is a matter of reducing the concrete space, reproducing its most relevant aspects, because, once the foundation of the question is apprehended, it will ground the entire system under study, which enables us to understand certain facts, concepts, systems, and processes that, otherwise, pose problems of capture. Simulation games converge with the qualities of simulation and the richness and attractiveness of playful activity (Marrón-Gaite, 2013).

Moreover, we highlight that the choices in simulation games, such as with Cities Skylines, enable the student to decide and monitor the outcome of their choices. The answer is not unique, but diverse. The gain in creativity and in experiencing conflicting situations make this means of entertainment a resource that can help in the teaching and learning process, keeping the focus on the two main subjects, the teacher and the student.

We agree with Jolly and Budke (2023) that the game Cities Skylines provides an opportunity for school children to get to know the complexity of cities and the design shows dimensions of sustainability that can be experienced by the player. Gaber (2007) points out that when playing, students are confronted with a series of planning problems that lead them to observe what is happening in their city. They must analyze the available visual and quantitative data; think and plan for a series of situations (population growth, congestion, housing, infrastructure, public space, health, and education).

And what is the role of the Geography teacher/researcher in all this? School Geography can foster practices that enable students to change their perception and become critically aware of the need for sustainable actions. We believe that the simulation game

SciELO Preprints - This document is a preprint and its current status is available at: https://doi.org/10.1590/SciELOPreprints.15991

Cities Skylines offers some possibilities to change the conception, the way of seeing and thinking about spatial organization, in the propositional sense for other sustainable urban configurations. This pedagogical practice is an effort to overcome the vision of a transmissible, decontextualized, repetitive, and traditional teaching of Geography, for a teaching with reflection and proposition of the students considering the problems of the world where they live.

In this sense, the approach to the sustainability theme with Cities Skylines enables cognitive learning (testing of the concepts that were taught), behavioral (improves critical thinking and problem-solving skills), and affective learning (change in learning perception and greater interest) (Khan; Zhao, 2021).

Moreover, Bereitschaft (2015) states that when used in the classroom as a formal pedagogical tool, students can benefit from critical evaluation of the simulation and reflection on the biases of the game and their own. For the author, the teacher can ask students to identify ways in which the simulation does not reflect specific attributes of concrete cities, and how their knowledge and experiences have shaped the way they approach the game.

The simulation game can be used at different times, at the beginning, throughout the development or end of the content, to introduce a new theme, elaborate concepts, verify the expansion of the knowledge acquired, to internalize concepts or review the knowledge developed in Geography classes.

In this sense, we use the digital simulation game Cities Skylines as a didactic resource in the teaching and learning process, aiming at the formation of concepts related to spatial organization and local scale by the problematization with the theme of basic sanitation, from the perspective of urban sustainability on which we focus below.

URBAN SUSTAINABILITY IN THE TEACHING OF GEOGRAPHY

The global environmental crisis is a recurring and alarming theme, resulting from humanity's conflictual relationship with nature. Nature is seen as a resource, separate from man and used not only to satisfy the essential needs of survival but also as a means of accumulating and reproducing capital. The consequences of this process have been extreme weather events such as floods, long periods of drought, temperatures extremely high or below the usual average, with considerable social and economic damage. These events are not

SciELO Preprints - This document is a preprint and its current status is available at: https://doi.org/10.1590/SciELOPreprints.15991

occasional, they result from our unsustainable relationship with the other forms of life on the planet, which exceeds the time limit of nature's renewal (Porto-Gonçalves, 2012; Boff, 2013).

The current economic model generates unequal living conditions in terms of housing, infrastructure, leisure, mobility, and vulnerability to extreme events. Inequality is materialized in the urban space by the forms and locations of occupations, restricted access to low-income people, degraded environment of rivers and native forest, incorrect disposal of sewage and solid waste, among other forms.

In cities, the complexity of the relationship between society and the physical environment is expanding. Thus, discussing sustainability permeates our perspective of the near future as humanity, of the existence and permanence of the conditions of habitability on planet Earth. The need is human, nature survives, renews, and remains by itself. It is urgent to discuss sustainability.

According to Limonad (2021), sustainability must contemplate humans and nature, it requires understanding that capitalism has colonized (a means of organizing domination) all spheres of social life, in order to impose its representation of space. For the author, it is necessary to overcome the society-nature rupture to propose another sustainability, which prioritizes social development to encourage and strengthen the potentialities, capacities, and needs of human beings in their relationships with each other and with nature.

For Schneider and Prestes (2021, p. 187, our translation), the "assumptions of sustainable cities articulate knowledge between the right to the city (which is capable of providing effective development) and through public policies, stimulating the population to build a way of life that prioritizes preservation." It is also necessary to practice sustainability in daily life, with a change in consumption habits, reducing our demands (Gadotti, 2008). For Conti and Vieira (2020, p. 25, our translation) "sustainability is the key for cities to be increasingly resilient, regenerative and livable." So "urban management at the beginning of the twenty-first century must seek to ensure the well-being of the community and the maintenance of environmental balance[1], with a view to ensuring the right to sustainable cities" (Moreira, 2014, p. 180, our translation).

Reflecting on sustainability at the city level involves understanding the functioning, the socio-environmental problem, the relationships between local and global problems, identifying possible solutions to propose substantial changes that have repercussions on a

[1] The term "environmental balance" is present in Article 1.0, sole paragraph, of the City Statute Law 10.257/01 (Brasil, 2001).

SciELO Preprints - This document is a preprint and its current status is available at: https://doi.org/10.1590/SciELOPreprints.15991

sustainable urban way of life. The school, in general, and the teaching of Geography, in particular, can contribute to this process.

In the teaching of Geography, the development of actions that mobilize critical reflection and citizen action are important referrals. At your disposal, there is a set of conceptual tools and languages. Among them, in this text, we present the game Cities Skylines, as a powerful didactic resource for learning the organization and dynamics of urban space and understanding social and environmental variables, since it offers a set of tools to explore the concept of sustainability via simulations.

We believe that the concept of sustainability can be a guide for teaching about cities in Geography, allowing the student to understand urban dynamics and the physical environment, with its specific rhythms and the necessary conditions for life in society and in line with social and environmental justice. To this end, we agree with Gadotti (2008, p.76, our translation) that the educational component should be seen critically, in the sense that the "preservation of the environment depends on an ecological conscience, and the formation of conscience depends on education." For the author, this can happen through learning the meaning of things from everyday life.

Thus, we agree with Gadotti (2008) that sustainability is a concept that should be linked to the teaching and learning process as a perspective of a future for humanity. The author highlights the destructive power that society has developed in relation to other forms of life on the planet, in which desertification, deforestation, and global warming have increased. For him, educating for sustainability requires a holistic paradigm.

In this line, we recognize that the authors Acselrad (1999), Boff (2013), Gadotti (2008), in the definitions of sustainability, highlight the word "consciousness." In the sense that humanity becomes aware of the environmental problem (Boff, 2013), the dissemination of ecological awareness and community recycling projects (Acselrad, 1999), which depend on education (Gadotti, 2008).

This term is also evoked by Cavalcanti (1998) to refer to "spatial awareness," which means the act of citizenship towards understanding the geography of things in order to be able to manipulate them in everyday life and to know the spatial dynamics of "innocent" daily practices, to give them a more critical and deeper meaning.

Thus, we recognize that it is essential to foster pedagogical practices that enable awareness and expand the reasoning of issues that interfere with urban sustainability. To do this, we use the game Cities Skylines to simulate with students how certain construction options, infrastructure, and the impact of the lack of sewage treatment interfere with urban

SciELO Preprints - This document is a preprint and its current status is available at: https://doi.org/10.1590/SciELOPreprints.15991

sustainability. Sustainability is herein understood as the set of processes and actions that are based on the preservation of the physical environment and the expansion and realization of human potentialities together, which includes giving the population access to decent living conditions.

BASIC SANITATION IN CITIES AND THE SIMULATION GAME CITIES SKYLINES

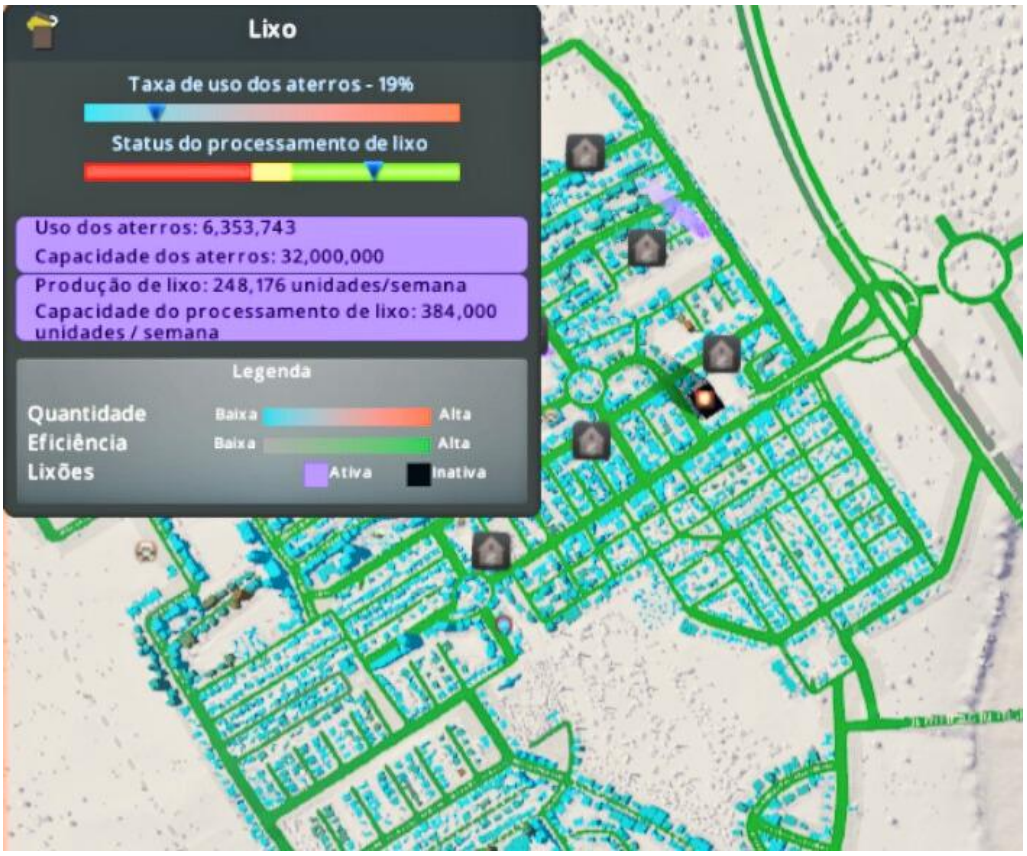
Basic sanitation corresponds to a set of essential services for economic and social development and for the preservation of the physical environment. According to Law 11.445/2007 art. 3 (Brasil, 2007, p.1), includes public services, infrastructures, and operational facilities for the supply of drinking water; sanitary sewage (from collection to treatment and adequate final disposal); urban cleaning; solid waste management; drainage and management of urban rainwater. The provision of these services effectively interferes with the living conditions of the population, impacts infant mortality rates, influences tourism, and affects education rates, among others.

From 1940 to 2010, the proportion of the Brazilian population living in cities increased from 31% to 84%, approximately 160 million urban residents (Maricato, 2011). According to UN data (2022), in 2021 56% of the people in the global total were in urban areas and it is believed that in 2050 it will increase to 68% of residents. This intense urbanization has not been accompanied by universal access to essential basic services, such as basic sanitation, in a short time.

Based on this, we believe that it is of fundamental importance to discuss urban sustainability with a focus on the provision of services related to basic sanitation. We used the digital game of city simulation Cities Skylines for the students to verify how the basic infrastructure of the city, linked to the provision of essential services, impacts the conservation of the physical environment and the living conditions of the population. In-game Cities Skylines (Figure 2), the mayor needs to guarantee access to drinking water, sewage collection, proper disposal of solid waste as well as other basic services to the population. All of these are immediate demands, which if not met result in abandonment of residents and, consequently, bankruptcy of the city.

Figure 2 – Monitoring the production and processing of solid waste

SciELO Preprints - This document is a preprint and its current status is available at: https://doi.org/10.1590/SciELOPreprints.15991



Source: Cities Skylines – Prepared by the authors.

In the concrete city, we know that the low-income population does not have the option of simply leaving the city because it does not have basic sanitation services. This is because the lack of economic resources forces them to seek other means to have access to water (not always of good quality), to solve on their own the destination of the sewage and solid waste generated. This distinct access to essential basic services is related to different income levels, professional activities, and ethnic distinctions, and, with this, the conditions of existing and living/surviving in cities (Santos, 2008), which also promotes environmental inequality (Gomes, Marquiana 2010).

In simulation with Cities Skylines, we noticed that as the city grows, so do the demands for services related to sanitation. The same occurs with the process of intensification of urbanization in concrete cities. The occupation of the soil is increased and with it the degradation of the physical environment, and, consequently, a huge volume of waste is produced, which is not always disposed of properly (Moreira, 2014).

In the simulated city, it is necessary to decide on the location of the final destination of the sanitary sewage in the river. When untreated sewage is discharged downstream from the place where the water is collected for urban supply, there is no direct negative repercussion

SciELO Preprints - This document is a preprint and its current status is available at: https://doi.org/10.1590/SciELOPreprints.15991

in budgetary terms or population dissatisfaction. The game does not show the relationship between a city under construction and its neighbor or the river basin. This fact needs to be problematized and contextualized in Geography classes so that there is no misunderstanding in relation to water pollution. According to Maricato (2011) water pollution is appalling, in the 1960s, the presence of heavy metals in water considered drinkable was found; In the 1990s, it was revealed that conventional treatment did not eliminate the presence of drug pollutants and herbicides in waters that receive effluents from ETES (Sanitary Sewage Treatment Station).

In turn, specifically in relation to solid waste, we realize that the simulated cities also reflect the society of consumption, of the large-scale production of products of low durability, soon converted into materials that should or could be recycled and others with possibly inappropriate destination. In this regard, Seabra (2003) points out that mass society is doomed to produce disposables in quantities that border on the absurd, that is, the productive logic of society, which aims to produce to replace (planned obsolescence), is responsible for the large amount of solid waste. Moreover, for the author, social consumption is unequal, as it results from income, which is also unequal; they are all actions logically linked in capitalist society.

Thus, the simulation game allows discussing the city model built in it, allowing the teacher to conduct problematizations such as: What is the consumption pattern show in the game and in everyday life? Does it differ according to income or location in the geographic space? Are the recycling policies of the game and of reality sufficient to solve the proper disposal of waste generated by society? Questions like these can be conducted from the simulation, with the insertion of geographical knowledge that allows students to think about actions and proposals for sustainable urban spaces.

Along these lines, Maricato (2011, p. 31, our translation) proposes measures in relation to sanitation, which include: “Integrate drainage, water supply, sewage, urban cleaning, waste management, land use, and environmental legislation systems […]”; “[…] maintain or recover the permeabilization of the soil surface to rainwater within a watershed.”

With Cities Skylines, the mayor needs to consider appropriate actions towards the preservation of the physical environment in line with the implementation of adequate basic sanitation conditions. The simulation game was used as a didactic resource, to learn about the city in an urban context similar to everyday life. This learning situations led students to reflect and build a geographical reasoning. This occurred via a didactic sequence in which students experienced the urban spatial organization and articulated geographical knowledge

SciELO Preprints - This document is a preprint and its current status is available at: https://doi.org/10.1590/SciELOPreprints.15991

and concepts that enabled them to think about Geography (Cavalcanti, 2019), as described below.

METHODOLOGICAL PROCEDURES

This research was developed for three months, with weekly activities related to the application of a didactic sequence, with twenty-eight students from the Integrated High School of the Federal Institute of Santa Catarina, Videira campus. The pedagogical actions consisted of weekly challenges with geographical issues that raised reflections on the importance of basic sanitation in a sustainable city.

To this end, we organized the didactic sequence with problematization regarding the adequate supply of services related to basic sanitation and the relationship with urban sustainability. After that, the systematization took place through the insertion of geographical knowledge with short texts related to situations and experiences via simulation. The synthesis of the sequence was through the resumption of the contents, concepts discussed, and completion of simulation diaries (systematic notes of the teams related to the construction and management of urban sanitation).

In this stage, weekly challenges were conducted for students to implement actions related to sanitary sewage, drinking water supply, and solid waste collection, providing a context of urban administration and management, while comparing them with the dynamics of a concrete urban space.

All the activities conducted in the didactic sequence (written activities and discussions), as well as the final sustainable city project were used for content analysis, based on Bardin (2011). To this end, we established five categories of analysis: problem solving; formation of concepts and use of geographical principles; learning of a sustainable city; and student perception of the teaching process. These processes are considered within three units of analysis: urban mobility, living conditions, and basic sanitation.

We considered the understanding of the basic sanitation theme, as the importance that the students attached to defining and simulating sanitary sewage and water supply in terms of location, access, distribution to the population, and relationship with the preservation of the physical environment. In the item solid waste, we sought in the students' expressions to identify the management and concern with the physical environment. We analyzed, according to the functionalities allowed with the simulator, whether it was built, how and where the

SciELO Preprints - This document is a preprint and its current status is available at: https://doi.org/10.1590/SciELOPreprints.15991

solid waste center was installed, and what were the policies related to recycling and water use. Chart 1 shows the levels of utilization of the teams that we analyzed.

Chart 1 – Levels of pedagogical performance of the teams: basic sanitation

Category – Sustainable City Learning	
Descriptor	**Criteria for classification/classification**
1 Unsatisfactory	When the team provided water and sewage collection to all residences, but was unable to implement the collection and disposal of solid waste to all inhabitants. When the understanding of sustainable city is incoherent in relation to the thematic unit of basic sanitation.
2 Partially satisfactory	When the team provided water and sewage collection to the entire population, it partially managed the demands related to solid waste. When the team understands, even if superficially, the importance of a sustainable city in relation to the thematic unit of basic sanitation.
3 Satisfactory	When the team satisfactorily organized the collection and disposal of solid waste, sanitary sewage, and water supply. When the team has an adequate understanding of the importance of sustainable cities for the thematic unit of basic sanitation.
4 Moderately satisfactory	When the team efficiently managed the city's basic sanitation. When the team broadly understands urban sustainability in the thematic unit of basic sanitation.

Source: Authors.

RESULTS AND DISCUSSIONS

In general, all teams demonstrated that they understood, in some way, the importance of access to basic sanitation services for urban sustainability. Moreover, they tried to make these services available to the residents of the simulated city and, therefore, no team obtained the "Unsatisfactory" performance. Two teams that achieved the "Partially Satisfactory" performance highlighted that:

> Garbage should be disposed of in disposal areas, and away from family residences and thus be incinerated, without harming health. Access to water must be made easier for people, and just as water treatment must be beneficial to citizens, and the less harmful it is to water, less will be the effect on health. The sewage must be destined to less populated areas, and put into practice its removal from less harmful areas, but not only does it have to work to cause less health risks, but it must also be treated to be less harmful to the environment (Report made by Luis and Bento[2], in the written activity on Basic sanitation[3] of 06.27.22).
>
> In the course of our activities, many buildings were abandoned, often because of the accumulation of garbage as well, and people were leaving the city. But all the problems served as a way to rethink and replan the city in a way that, at least, most of the population was satisfied. So, as soon as we started over, we tried to avoid the same mistakes that we had in past times we played and so we were able to grow the city and increase our population (Report made by Katia, in the presentation of the Sustainable City Project on 07/11/22).

[2] The names of the students were changed (fictitious) to preserve the identity of the participants.

[3] Answer to the question: "In a sustainable city, what would basic sanitation be like (solid waste, access to water and sewage disposal)? Relate to the text and argue" (activity written in class).

SciELO Preprints - This document is a preprint and its current status is available at: https://doi.org/10.1590/SciELOPreprints.15991

In these reports, we found that the students were learning about urban sustainability from the reports that the teams made about the location of garbage disposal and the management of solid waste. In general, they highlighted the importance of treated water, the proper disposal of sanitary sewage, and the relationship between the degradation of the physical environment and health problems. For Acselrad (1999, p. 82) urban unsustainability is "a social expression for thermodynamic irreversibility." For the author, as a way of minimizing the impact of urban practices, it would be up to "urban planning to minimize energy degradation and slow down the trajectory of irreversibility" and, for this, it should "adopt technologies that save space, matter, energy, and aimed at recycling materials."

These teams could not effectively solve the demands related to basic sanitation, which was the main reason for previous failures, but they started over, recognized their mistakes and learned by making and reflecting on the choices, in an active and practical way. Along these lines, Kiili (2007) highlights the authenticity, collaboration, and learning by doing that games allow. For him, games allow students to test hypotheses creatively and reflect on the results.

Two teams that achieved the "Partially Satisfactory" performance highlighted that:

> Basic sanitation helps to improve the quality of life, because with water treatment the population does not drink water with various waste and also helps in cleaning the rivers. And the garbage ends up affecting the physical environment in a bad way, as the accumulation creates leachate that affects the soil and also the air quality (Report made by Fernanda and Vicente in the Simulation Diary of 06.06.22).
> In a sustainable city, it is necessary to carry out the collection, treatment, supply of residences/buildings, collection of solid waste and dumping, this water must be treated to be returned to the environment in safe conditions to prevent neighboring cities, or the same, from having a drop in health and quality of life (Report made by Ariana, Angela, Antônio, in the written activity on Basic Sanitation on 06.27.22).

In the reports, the progress in learning about sustainable cities is evident. The relationship established by the students between variables involving basic sanitation with living conditions, water quality, and preservation of water resources. Moreover, they expanded the discussion in relation to atmospheric and underground pollution as a result of the inadequate disposal of solid waste. They made observations, analyses and inferences about pollution, the extent of the city, soil and air degradation, and the risk of disease.

According to Ayach, Guimarães and Cappi, (2012, p. 52) the research points to a "[…] strong link between the inadequacy of essential sanitation services and health. The deficiency of these services generates the contamination of surface and underground water sources, and, consequently, implications for the health of the population, due to the emergence of waterborne diseases." In this sense, the universalization of basic sanitation is a fundamental point to reduce this type of disease (Gomes, Matheus 2022).

SciELO Preprints - This document is a preprint and its current status is available at: https://doi.org/10.1590/SciELOPreprints.15991

Moreover, the teams that achieved this performance, in addition to relating sustainability to the need for basic sanitation, were also able to satisfactorily manage the solid waste produced in the simulated city, offering water supply and sewage services to all residences. Torres-Porras and Arrebola (2018) highlight that a sustainable city is designed to consider the environmental impact, and in which its inhabitants are aware of minimizing the consumption of resources, reducing waste and air or water pollution.

Consequently, the team that obtained a “Fully satisfactory” performance highlighted that:

> In a sustainable city, basic sanitation must be thought of very carefully because the consequences affect us directly. For cities to be sustainable, we must think about the implementation of policies such as: recycling and energy measures, education in relation to waste production and invest in sustainable ways of disposing of and recycling garbage and basic sanitation. The biggest concern of a sustainable city is the excessive production of garbage, with the increase of the city, garbage increases and with the disrespect of recycling policies we are producing more and more garbage (Report made by Mauricio, Tanea, Josias, in the written activity on Basic Sanitation of the day 27.06.22).

We identified in the comments above, the expansion of the discussion in terms of basic sanitation with sustainability. The reflections deepen and move on to the level of broader measures with the implementation of public policies (figure 3), including recycling, sewage treatment, and the correct disposal of solid waste.

Figure 3 – Public policies regarding solid residues and water use

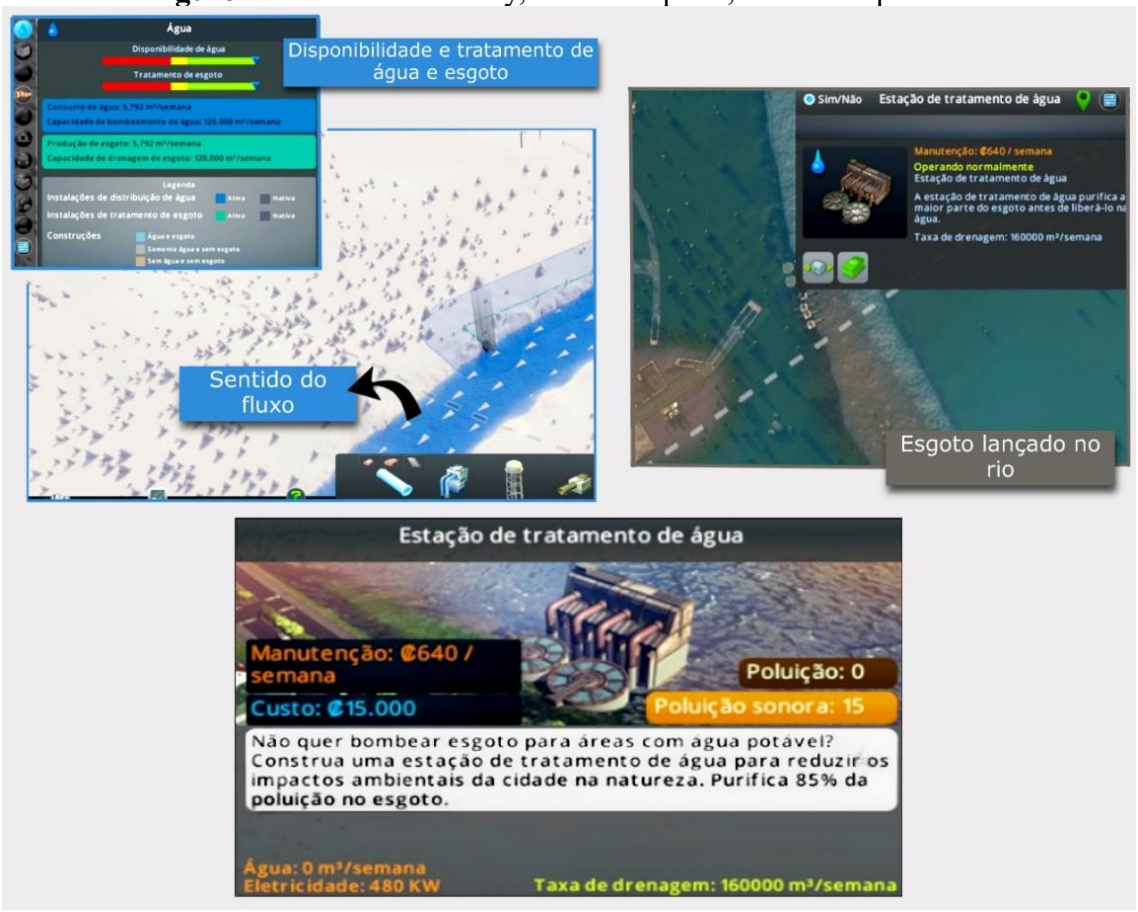


Source: Cities Skylines – Prepared by the authors.

SciELO Preprints - This document is a preprint and its current status is available at: https://doi.org/10.1590/SciELOPreprints.15991

They clarify that pollution, without sewage treatment, affects other water bodies as a result of the direct connection. They realize that the problem of solid waste is in production and excessive consumption that demands more areas for final disposal, requiring the government to enforce regulations and encourage proper management. Added to this are the measures taken to spatially organize the final destination of solid waste, away from water courses to avoid contamination of river waters (Figure 4), together with the implementation of public policies as a way to manage and encourage measures aimed at preserving the physical environment.

Figure 4 – Water availability, treatment plant, and water pollution



Source: Cities Skylines – Prepared by the authors.

For Siqueira and Moraes (2009, p. 2118), the simple act of consuming products "provokes, interferes and disseminates social phenomena based on exclusion and that affects the environmental and collective health of the planet, it is time to demand changes in current public policies and readjust the current ways of life in society."

Moreover, we led students to make comparisons between what happens in the simulation with the concrete world, the lived space. We raise important reflections on the

SciELO Preprints - This document is a preprint and its current status is available at: https://doi.org/10.1590/SciELOPreprints.15991

reasons for the differences and similarities between these spaces (virtual and concrete), made possible through weekly questions ("*Does the game situation resemble what happens in a real city? Explain*"). Below is the answer on the first day of simulation and on the last day of one of the teams:

> Yes, because when there is a lack of resources and there are no opportunities, people are unhappy, just like in the game. Yes, because the problems that appeared to us and their respective consequences happen in real life, harming the city, the population, and the environment (Report made by Eduardo, Lais, Katia in the simulation diary 16.05.22 and 27.06.22).

The problems mentioned by students may involve, for example, the lack of adequate access to essential services, such as basic sanitation. This impacts both the living conditions in the cities and the preservation of the physical environment.

CONCLUSION

By proposing this research, we asked ourselves how to involve and motivate students to learn Geography in the current technological context. At the same time, we consider that studying requires dedication, attention, and focus so that knowledge can be internalized. However, we believe that teaching activities can be planned with new technologies and, thus, generate involvement.

Our proposal was elaborated with the digital game of city simulation, Cities Skylines, considering that it has great immersive potential, its approaches to city building can be used in teaching by reviewing it as an organization of society itself. By this, we do not mean that only digital games need to be used in classes for learning to occur, but that there is potential in this resource and that it can be applied to the teaching and learning of the city in Geography.

We see the various possibilities that Cities Skylines offers in terms of understanding, visualization, and manipulation of urban variables, especially in the basic sanitation category in relation to the need for adequate supply of services that include the collection and distribution of drinking water, management of sanitary sewage, and adequate disposal of urban solid waste.

It is undeniable that today's society is experiencing a global environmental crisis, and in the urban space this problem is seen more intensely and directly by a greater number of people, due to the excessive consumption of natural resources, deforestation, contamination and atmospheric, water, and soil pollution. The lack of basic sanitation aggravates urban

SciELO Preprints - This document is a preprint and its current status is available at: https://doi.org/10.1590/SciELOPreprints.15991

problems, the inequality of access to housing on urban land forces the most vulnerable to live in polluted spaces with little or no infrastructure.

Reflecting on sustainability involves questioning the urban structure in which we are inserted, both in terms of access to basic services, as well as consumption and the consequences of these for the preservation of the physical environment. With Cities Skylines, the students observed and managed a growing city, with demands, budget, and urban problems typical of a concrete space.

We found that the students learned by doing, through the testing of variables, by trying to meet the challenges in the construction of the sustainable urban structure, in the management of problems related to basic sanitation, and by the dynamic visualization of a city. At the same time, geographical knowledge was inserted, as a way to sustain the debates, deepening game issues, and correlating aspects of simulation with everyday life.

Finally, we believe that through the simulation with teacher mediation, students were able to learn about the importance of sustainable cities related to adequate living conditions linked mainly to basic sanitation and the preservation of the physical environment.

References

ACSELRAD, H. Discursos da sustentabilidade urbana. Discursos da sustentabilidade urbana. **Revista Brasileira de Estudos Urbanos e Regionais**, (1), 79, 1999. https://doi.org/10.22296/2317-1529.1999n1p79

AYACH, L. R.; GUIMARÃES, S. T. de L..; CAPPI, N. Saúde, saneamento e percepção de riscos ambientais urbanos. **Caderno de Geografia**, v.22, n.37, p.47-94, 2012. ISSN: 0103-8427

BARDIN, L. **Análise de conteúdo**. Edição revista e ampliada. Tradução Luís Antero Reto e Augusto Pinheiro. São Paulo: Edições 70, 2011.

BEREITSCHAFT, B. Gods of the City? Reflecting on City Building Games as an Early Introduction to Urban Systems. **Journal of Geography**, 115:2, 51-60, 2015. DOI: https://doi.org/10.1080/00221341.2015.1070366

BOFF, L. **La sostenibilidad: Qué es y qué no es**. Espanha: SalTerrae, 2013.

SciELO Preprints - This document is a preprint and its current status is available at: https://doi.org/10.1590/SciELOPreprints.15991

BRASIL. Lei Nº 11.445, de 5 de janeiro de 2007**. Lei de saneamento**. Estabelece diretrizes nacionais para o saneamento básico. Brasília, Diário Oficial da União - Seção 1 - 8/1/2007.

CAVALCANTI, L. de S. **Geografia, escola e construção de conhecimentos**. Campinas, São Paulo: Papirus, 1998.

CAVALCANTI, L. de S. **Pensar pela geografia: ensino e relevância social**. Goiânia: C&A Alfa Comunicação, 2019.

CONTI, D.; VIEIRA, V. L. Governos locais e sociedade civil: a nova democracia urbana para o desenvolvimento de cidades sustentáveis. *In*: CONTI, D. de M.; VIEIRA, V. L. R. (org.). **O futuro das cidades: Sustentabilidade, Inteligência Urbana e Modelos de Viabilidade Utilizando PPPS e Concessões.** São Paulo: Casa de Soluções e Editora, 2020, p. 24-34.

GABER, J. Simulating Planning: SimCity as a Pedagogical Tool. **Journal of Planning Education and Research**, n. 27, p. 113 – 121, 2007. doi.org/10.1177/0739456X07305791

GADOTTI, M. Educar para a sustentabilidade. **Inclusão Social**, Brasília, v.3, n. 1, p. 75-78, out. 2007/mar. 2008.

GOMES, M. de F. V. B. Desigualdade socioambiental no espaço urbano de Guarapuava. **RAEGA - O Espaço Geográfico em Análise**, *[S. l.]*, v. 20, 2010. DOI: 10.5380/raega.v20i0.20614.

GOMES, M. F. B. Saneamento básico: promotor de saúde pública e sustentabilidade. *In*: FERREIRA, J.G.; FIGUEIREDO, F.F.; SILVEIRA, R. M. daC. (org.). **Socioeconomia do Meio Ambiente e Política Ambiental**. 1°ed. Rio de Janeiro: Letra capital, 2022, p. 103-127.

JOLLY R.; BUDKE A. Assessing the Extent to Which Players Can Build Sustainable Cities in the Digital City-Builder Game “Cities: Skylines”. **Sustainability**. 15(14):10780, 2023.

KHAN, T. A.; ZHAO, X. Perceptions of Students for a Gamification Approach: Cities Skylines as a Pedagogical Tool in Urban Planning Education**.** IFIP International Federation

SciELO Preprints - This document is a preprint and its current status is available at: https://doi.org/10.1590/SciELOPreprints.15991

for Information Processing: Published by **Springer Nature**. Switzerland AG, p. 763–773, 2021. https://doi.org/10.1007/978-3-030-85447-8_64

KIILI, K. Foundation for problema-based gaming. **British Jornal of Education Technology**. Vol. 38, n. 3, p. 394-404, 2007. doi.org/10.1111/j.1467-8535.2007.00704.x

LIMONAD, E. Por uma outra sustentabilidade um diálogo entre Lefebvre e o pensamento decolonial. **Boletim Goiano de Geografia.** v. 41: e70787, p. 1-30, 2021. DOI: 10.5216/BGG.v41.70787

MARICATO, E. A cidade sustentável. *In*: MACHADO, Brenda. Related papers. **9° Congresso Nacional de Sindicatos de Engenheiros (Consege**), Porto Velho (Rondônia), 2011, p. 11-32.

MARRÓN-GAITE, M. J. Los juegos de simulación como recurso didáctico para la enseñanza de la geografía. **Geographical Didactics,** (1), p. 45-56, 2013.

MOREIRA, D. de A. O direito a cidades sustentáveis. **Revista de Direito da Cidade**. Vol. 06, n°. 02, 2014, p.179-200. ISSN 2317-7721

ONU – Organização das Nações Unidas. **World Cities Report 2022: Envisaging the future os cities**. United Nations Human Settlements Programme (UN-Habitat). Disponível em: https://unhabitat.org/sites/default/files/2022/06/wcr_2022.pdf Acesso em: 14/11/2022.

PORTO-GONÇALVES, C. W. **A globalização da natureza e a natureza da globalização**. 4°edição. Rio de Janeiro: Civilização Brasileira, 2012.

SANTOS, M. **Manual de geografia urbana**. 3. Edição – São Paulo: Editora a USP, 2008.

SCHNEIDER, E. J.; PRESTES, F. da S. Cidades como territórios educativos: possiblidade e desafios na educação para o trânsito. *In*: DEON, A. R.; CALLAI, H. C.; OLIVEIRA, T. D. de (org.). **A cidade como lugar/espaço para o ensino e aprendizagem** (Coleção cidade: conhecer e interpretar para compreender o mundo da vida VOL III) – Curitiba: CRV, 2021, p. 187-198

SciELO Preprints - This document is a preprint and its current status is available at: https://doi.org/10.1590/SciELOPreprints.15991

SEABRA, O. C. de L. Os embates entre as questões ambientais e sociais no urbano. *In*: CARLOS, A. F. A.; LEMOS, A. I. G. (org.). **Dilemas Urbanos: novas abordagens sobre a cidade** – São Paulo: Contexto, 2003, p. 308-322.

SIQUEIRA, M. M.; MORAES, M. S. de. **Saúde coletiva, resíduos sólidos urbanos e os catadores de lixo**. Ciência saúde coletiva 14 (6), p.2115-2122, 2009. https://doi.org/10.1590/S1413-81232009000600018

TORRES-PORRAS, J.; ARREBOLA, J. C. Construyendo la ciudad sostenible en el Grado de Educación Primária. **Revista Eureka sobre Enseñanza y Divulgación de las Ciencias,** 15 (2), 2501, p. 1-15, 2018. DOI: 10.25267/Rev_Eureka_ensen_divulg_cienc.2018.v15. i2.2501

SciELO Preprints - This document is a preprint and its current status is available at: https://doi.org/10.1590/SciELOPreprints.15991

Declaração de conflito de interesse:

O autor declara que não há conflito de interesse.

Declaração de disponibilidade de dados:

Todo o conjunto de dados de apoio aos resultados deste estudo foi publicado no próprio artigo.

Declaração de uso de IA

Não houve utilização de ferramentas de Inteligência Artificial.

Declaração de contribuição dos autores:

Marquiana de Freitas Vilas Boas Gomes: Elaboração e estruturação do artigo, pesquisa do tema, execução dos procedimentos metodológicos, análise e discussão dos resultados.

Solange Francieli Vieira: Análise dos dados e resultados, revisão e elaboração final do manuscrito.

This preprint was submitted under the following conditions:

- The authors declare that the necessary Terms of Free and Informed Consent of participants or patients in the research were obtained and are described in the manuscript, when applicable.
- The authors declare that the preparation of the manuscript followed the ethical norms of scientific communication.
- The authors declare that they are aware that they are solely responsible for the content of the preprint and that the deposit in SciELO Preprints does not mean any commitment on the part of SciELO, except its preservation and dissemination.
- The authors declare that the data, applications, and other content underlying the manuscript are referenced.
- The deposited manuscript is in PDF format.
- The authors declare that the research that originated the manuscript followed good ethical practices and that the necessary approvals from research ethics committees, when applicable, are described in the manuscript.
- The authors declare that once a manuscript is posted on the SciELO Preprints server, it can only be taken down on request to the SciELO Preprints server Editorial Secretariat, who will post a retraction notice in its place.
- The authors agree that the approved manuscript will be made available under a Creative Commons CC-BY license.
- The submitting author declares that the contributions of all authors and conflict of interest statement are included explicitly and in specific sections of the manuscript.
- The authors declare that the manuscript was not deposited and/or previously made available on another preprint server or published by a journal.
- If the manuscript is being reviewed or being prepared for publishing but not yet published by a journal, the authors declare that they have received authorization from the journal to make this deposit.
- The submitting author declares that all authors of the manuscript agree with the submission to SciELO Preprints.