# GeoMinasCraft
## A Serious Geogame for Geographical Visualization and Exploration

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# Chapter 30
# GeoMinasCraft: A Serious Geogame for Geographical Visualization and Exploration

**Ítalo Sousa de Sena, Alenka Poplin, and Bruno de Andrade**

**Abstract** This chapter concentrates on the implementation of the geogame GeoMinasCraft and its use for geographical virtual explorations. The game was implemented to study the use of geospatial data for the visualizations of landscapes in a serious game. The users/players can take on an adventure, explore the landscapes, learn about geodiversity, and face different challenges. The game takes us to the City of Ouro Preto in Minas Gerais in Brazil. The city was selected due to its historical significance and socio-cultural values. We used satellite images and transformed them into blocks imitating these real-world landscapes and cities in Minecraft. We tested the game prototype with nine students which gave us the needed feedback for the improvements of the first prototype. This chapter summarizes the game concept, its implementation, and the testing results. We conclude the chapter with a discussion and further research directions.

**Keywords** Minecraft · Landscape · Geodiversity · Playtest · Values

## 30.1 Introduction

Although research on the use of gaming for serious purposes has increased recently (Anderson et al. 2010), the use of digital games to support geoconservation purposes,

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such as geodiversity in natural and cultural heritage landscape sites, or for enhancing (and monitoring) open air museum or geoparks visits, has been less considered and documented. Games can be used to craft virtual spaces capable to tell stories in an immersive and interactive way (Jenkins 2004). They are usually set in an imaginary, fictional environment. We are interested in how to represent real-world environments and landscapes in games. We are interested in the possibility of creating geographical visualizations and game-based concepts that may enable the player/explorer to interact with these virtual landscapes and learn about them.

Landscapes are products of long-term interactions of human activities with natural forms (Miklós et al. 2019). These landscapes are diverse in its nature and researchers (Gray 2013) define it as geodiversity. Geodiversity represents the diversity of geological forms and processes (Gray 2013, 2018; Hjort et al. 2015). The concept emerged in early 90 s as a complementary idea to biodiversity representing the abiotic portion of the nature (Sharples 1993).

We selected Minecraft as the game-environment that may enable to explore the use of games and their support in learning about geodiversity. The Minecraft game environment is a remarkably successful example of how simple mechanics and aesthetics can engage people to explore this virtual environment. It is based on the idea of building blocks that can be used to model the game environment and its objects. We implemented a game prototype GeoMinasCraft in Minecraft game environment. The game is an experiment in creating realistic landscapes and aims to provide a playful tool for the users/players to explore and learn about geodiversity of landscapes. It takes us into the City of Ouro Preto in the state of Minas Gerais, Brazil. The city is a World Heritage Site listed by UNESCO in 1987 due to its historic landscape shaped by 300 years of mining exploration and expressive Baroque architecture. Recent urban growth processes have been threatening its heritage landscape values. Landslides represent an emerging risk in the city.

The first goal of this chapter is to explore how realistically the geodiverse landscape context of Ouro Preto can be visualized in a virtual game-based environment Minecraft. The second goal is to present the first game prototype and the results of initial testing. The first game prototype was tested by nine students in the age from 17 to 43 years old. The students came from a remarkably diverse, multi-cultural and international background studying at Iowa State University, USA. The prototype was developed within the first author's PhD research and tested during his research period at Iowa State University (ISU) where he was supervised by the second author of this chapter. The playtest sessions occurred in February 2019 at ISU in order to get the feedback on the developed prototype.

The results of playtesting show that the participants can easily accomplish basic navigation and communication in the game. They had more substantial difficulties in a more complex task determined for them to identify three places at which a visitors' center can be built. The results of this testing influenced further development of the game. This paper summarizes the implementation of the first prototype of GeoMinasCraft game and the main testing results. We conclude the chapter with the reflection of the results and further research ideas.

## 30.2 Representing Realistic Landscapes in Serious Geogames

### *30.2.1 Serious Geogames and Their Development*

Geospatial technologies represent new opportunities for visualization and interaction with environments implemented in game engines. Such engines have significantly increased the capacity of integrating immersive 2D and 3D simulations (Linowes 2015), contributing to the development of virtual geographic environments (Ugwitz et al. 2019; Ahlqvist 2011).

Game design concepts aligned with spatial data visualization technologies provide resources for the development of serious geogames. Geogames are characterized by representing graphically real world systems, capable of promoting comprehension of the object system by a particular context of gameplay (Ahlqvist and Schileder 2018). Such games are often referred to as spatial games, geogame or sometimes location-based games.

Serious geogames can be used for learning in a variety of disciplines including cultural heritage landscapes and civic engagement (de Andrade et al. 2020; de Sena and de Andrade 2018; de Sena et al. 2018; Callaghan 2016), urban planning (Poplin 2012, 2014; Poplin et al. 2017; Devisch et al. 2016) and geodesign (McDaniel 2018; Scholten et al. 2017). Experiences provided by geogames favor the increase of spatial awareness, showing the intrinsic potential of games for the development of mental maps and geovisualization of the landscape (de Sena 2019).

The GeoMinasCraft geogame as a virtual reconstruction in Minecraft followed Jenkins (2004) concept of environmental storytelling, where the game design idea is developed to tell a story from and along with the environment. The goal of the storytelling aspect is to allow players to collect glimpses of the main story from the experience of visualizing and experiencing conflicts within the game environment. The environment becomes the protagonist of the geogame.

### *30.2.2 Modeling Realistic Landscapes in Minecraft*

Minecraft is currently the most successful game in the world with 200 million copies being sold across the world. Officially it was first released in 2011. In Minecraft everything—including the environment, the characters, the landscapes—is represented in a form of blocks. They compose the represented game elements including the environment and other objects such as for example monsters and other figures. The player can explore procedural generated environments, build in these environments using the available blocks, and get immersed in exciting game adventures.

Recently, researchers (Formosa 2014, 2015; Elmerghany and Paulus 2017; Scholten et al. 2017; Lecordix et al. 2018; de Andrade et al. 2020) started exploring the possibility to implement more realistic landscapes on a 1:1 scale (Table 30.1).

**Table 30.1** Articles describing realistic visualizations of landscapes in Minecraft

| Authors | Represented landscape | Procedures | Software |
|---|---|---|---|
| Formosa (2014, 2015) | Terrain | Converting LiDAR data to raster data<br>Converting raster data to Minecraft | ArcGIS<br>Lastools<br>WorldPinter |
| Elmerghany and Paulus (2017) | Terrain, land cover, rivers, roads, buildings | Applies the same methodology for the generation of the terrain as found in Formosa (2014)<br>Converting OpenStreetMap data<br>Using orthophotos raster data | FME<br>WorldPinter |
| Scholten et al. (2017) | Terrain, land cover, rivers, roads, buildings, geology | Cell decomposition of spatial data to raster data sorting it by tiles<br>Aggregating the data layers afterwards through cloud computing | PostGIS<br>Python<br>Microsoft Azure Batch |
| Lecordix et al. (2018) | Terrain, land cover, rivers, roads, buildings | Retrieve data from IGN and process it through Java coding | OpenLayers (WMTS)<br>PHP coding |
| de Andrade et al. (2020) | Terrain; vegetation, roads, buildings | Interpolation of SRTM data to 1:1 scale, importing to WorldPainter to insert land cover as layers. Buildings were placed using *.stl 3D | QGIS, MicroDEM, SketchUp, WorldPainter, MCEdit |

We refer to realistic landscapes in this chapter as the landscapes that were generated directly from geospatial data, regardless the representation scale of the data. Geospatial data representing geographic spaces by taking pictures of parts of the Earth (satellite images, airborne images) or measuring the earth (i.e., digital elevation model, LiDAR data) or from a variety of other geospatial data sources.

Research on representing and visualizing real-world environments in Minecraft is limited to a few recent articles summarized in Table 30.1. In general, there is little research available which concentrates on a realistic representation of game environment. Published research focused on representing a 1:1 scale model of the landscape in Minecraft. Their main objective was to produce a virtual environment for urban planning and participation. Taking advantage of a real-world scale representation, the authors put efforts on representing as many landscape features as possible to improve the virtual exploration. The studies presented in Table 30.1 also do not propose a narrative or game-mechanics to support players' behavior in the game environment.

In our perspective, representing real landscape in Minecraft can be useful for exploration and interpretation, regardless the scale of representation. Based on that, it is our goal to contribute to this research and to explore the capabilities of Minecraft to represent living environments, with a story embed in it. We are particularly interested in ways in which diverse landscapes and their geodiversity highlighting the elevation, waters, vegetation, geology, and buildings can be represented in a game environment. We also experimented on how exploring a different height scale (vertical exaggeration) could improve the landscape representation. We considered the exaggeration of the remarkable geomorphological feature that compose Ouro Preto landscape. Our study also proposes a way to produce a game narrative to drive players to accomplish tasks in the game.

## 30.3 Research Focus: Landscape Perception in Virtual Environment

### *30.3.1 Research Questions*

We are interested in representing geodiversity in a geogame through the five qualities of the imageability (Lynch 1960) as a way to compose the landscape structure and to build a virtual game-environment. There are two main goals of this research. The first goal is to explore how to visualize realistic landscapes in Minecraft. We explore the capability of Minecraft to represent diverse landscapes in its game-based environment. The diversity comes in the form of a digital elevation model and the representation of mines, houses, trees, and other objects representing the living environment. The second goal is to study the interaction of the player with these visualizations as well as with the implemented game characters.

Our main research questions are formulated as follows:

- How to visualize selected landscapes in Minecraft using geospatial data? The main goal is to represent these landscapes as realistically as possible to stimulate player's perception.
- How to enable the user/player to interact with the game elements, navigate in the game and explore the visualized landscapes?

To be able to study the implementation of geodiversity of a landscape we selected a case study of the City of Ouro Preto in Minas Gerais, Brazil due to its significant landscape.

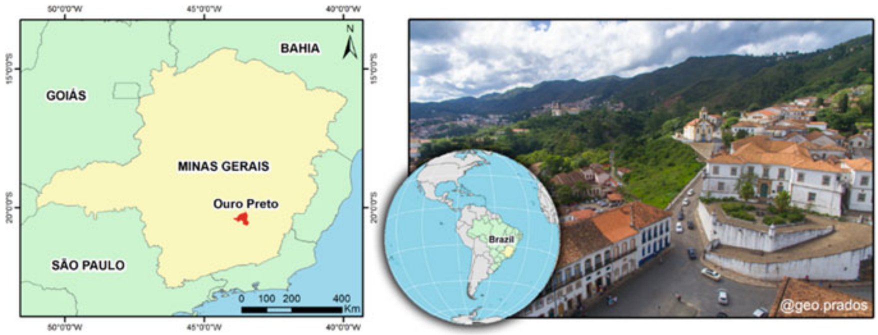


**Fig. 30.1** Map of Ouro Preto location

### *30.3.2 Case Study: City of Ouro Preto in the State of Minas Gerais, Brazil*

The landscape surrounding the City of Ouro Preto is geologically and geomorphologically significant and represents an example of a remarkably diverse landscape. It combines man-made changes of the landscape representing by historic sites and natural changes of landscape and its geomorphological structures.

The City of Ouro Preto is in the state of Minas Gerais marked yellow on the map (Fig. 30.1) in Brazil marked green on the map. The city has a 300-year-old historic landscape shaped over the years by two main processes; the Brazilian gold cycle (XVIII and XIX centuries) and the recent urban growth towards the former mining areas, which started in the 60's. The picture on Fig. 30.1 on the right-hand side shows the city of Ouro Preto with its historical buildings.

The city of Ouro Preto has an important role in the state due to its architectural, religious, and socio-cultural heritage. The city and the surrounding landscape were listed as a World Heritage Site by UNESCO in 1980. Policies for the conservation of local historical heritage are in place guaranteeing the safeguarding of individual buildings. Recent irregular urban developments contributed to the degradation of the landscape surrounding the city's historic core (de Costa 2011).

## 30.4 GeoMinasCraft Game Design and Prototype Implementation

### *30.4.1 Game Concept*

The game-concept is based in a narrative that presents Ouro Preto historic and geodiverse landscape to the player. The player takes a role of an explorer/adventurer exploring the landscape. To motivate players to move through the virtual environment, we implemented a quest-based game where the explorer needs to collect hidden objects in the landscape. The player can communicate with different characters in the game and get information from them. The activity diagram presents an overview of the game mechanics, the decision-making points, and the workflow in the game (Fig. 30.2).

The player enters the game and can talk with an implemented character called Ana. After that, the player can study the tutorial and ways in which the game can be played. The main decision-making points are marked yellow in the diagram.

The game story is based on three quests clearly marked in Fig. 30.2. The first quest consists in inviting the player to walk through the space, referring to the spatial location and orienting. In the second quest player must bring rock and mineral samples to a geologist located inside a former gold mine. To be able to do that the player has to interact with different objects and fight a spider which can kill the player forcing her to start the journey from the beginning. The third quest has two main tasks consisting of finding suitable places on which she can build a visitor center.

### *30.4.2 Creation of Realistic Digital Landscapes in Minecraft*

One of the goals of this research was to visualize the landscape of the City of Ouro Preto and its surrounding in Minecraft. Figure 30.3 shows the workflow used for processing of elevation data into a Minecraft visualization, to prioritize Ouro Preto ridge. The input data included the digital elevation model (DEM) from ALOS-PALSAR, obtained from NASA Earth Data portal.

The DEM image was originally 12 m resolution which required a pre-processing step in which it was interpolated to 5 m resolution. The raster elevation data was converted to points and then used as samples to produce a new DEM. The resultant raster was normalized to fit in a range of 1 to 255, to adapt it to Minecraft maximum stackable blocks.

Exchange transform and load (ETL) operations were applied through FME (Feature Manipulation Engine) software to insert a vertical exaggeration in the Ouro Preto Ridge area and to highlight its representativeness as a landmark. To make the ridge a focal point, making it steeper, we decided to represent it in a 1:5 scale, stretching its height and compressing its length.

After that, we converted the DEM to a level.dat file compatible with Minecraft Java Edition using FME. We performed an in-game navigation through the generated virtual environment to validate the scale and vertical exaggeration. Figure 30.4 shows the resulting visualization of the DEM with vertical exaggeration implemented.

To allocate rivers along with drainage features in the landscape, we produced a model for hydrology analysis using model builder tool in ArcMap 10.7. We classified the streams by Strahler order scale to apply a width and depth rule based on each stream order (Fig. 30.5). The first order streams were represented as one block deep and one block wide, second order stream were represented as one block deep and

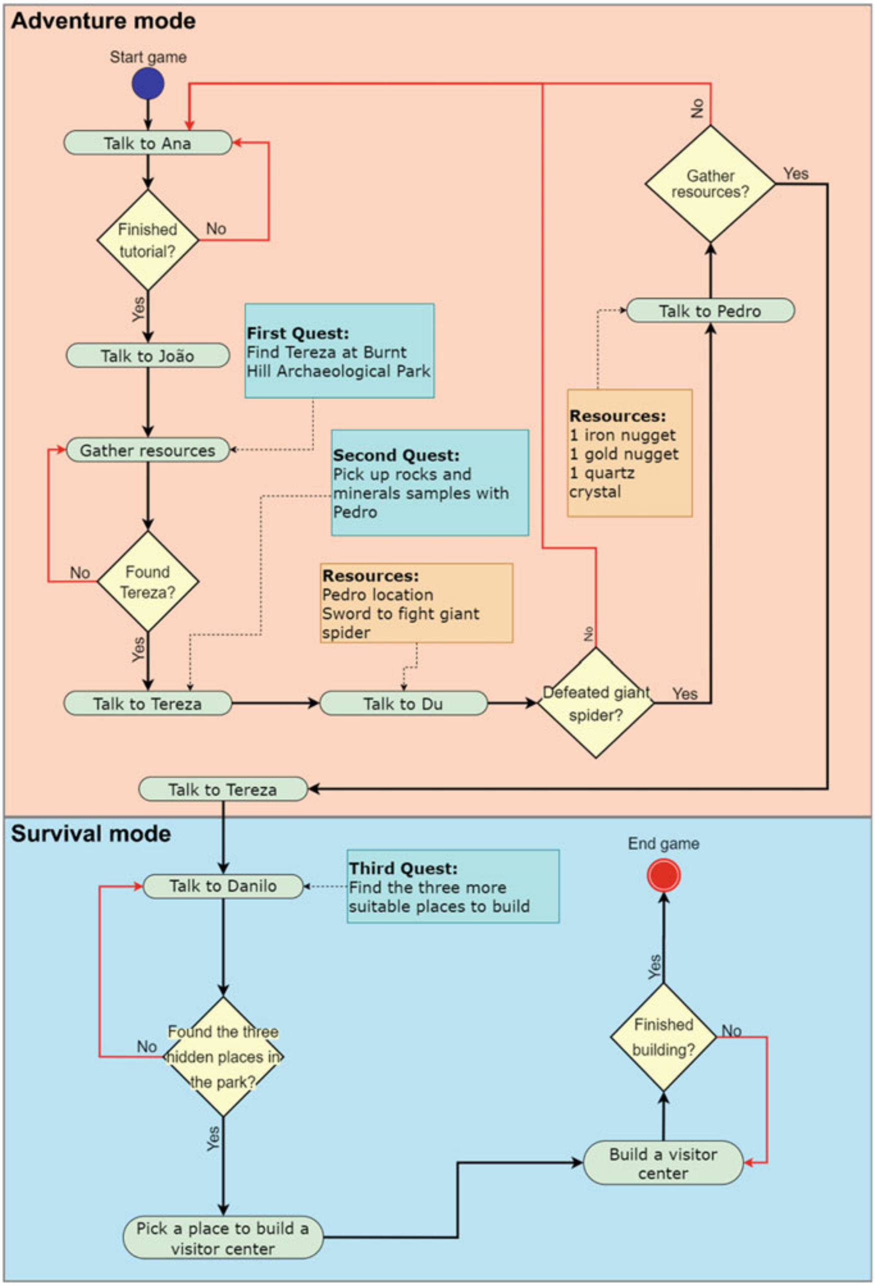


**Fig. 30.2** Game prototype activity diagram

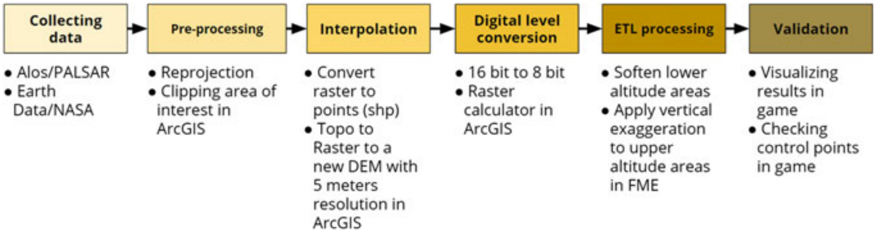


**Fig. 30.3** Topographic data processing workflow

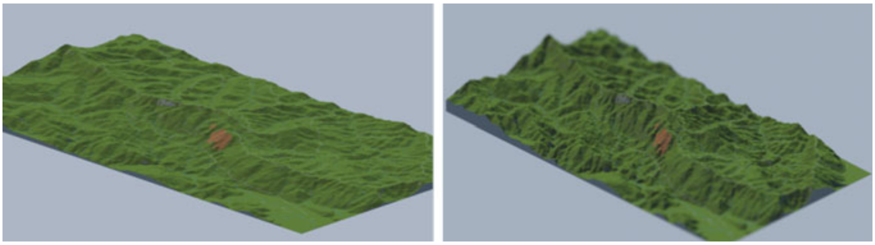

**Fig. 30.4** Topographic data visualized in Minecraft without vertical exaggeration (left) and with vertical exaggeration applied on the ridge area (right)

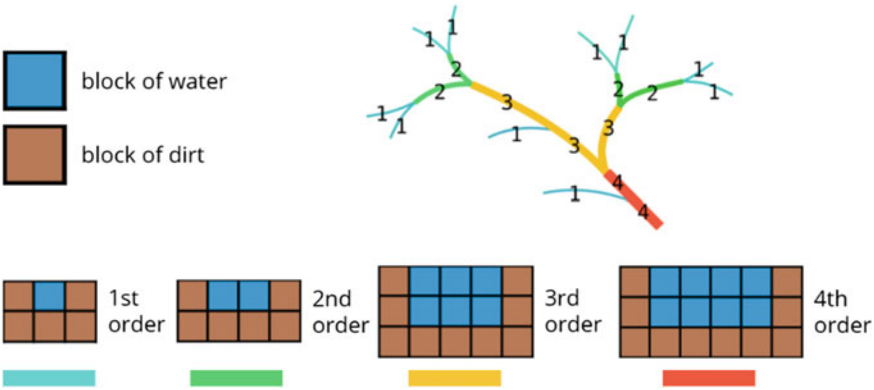


**Fig. 30.5** Conceptual rule for stream order depth and width in Minecraft

two blocks width and so forth. We implemented it in the game environment using FME. To represent rock outcrops, using FME we generated a slope analysis using the original DEM, extracting areas with high degree of slope, and associating it as stone blocks to compose the landscape.

Roads, streets, and trails were placed on the terrain using ETL processing on FME software. Vegetation layer was produced with the help of a satellite image processing from Sentinel-2. A range of the normalized difference vegetation index (NDVI) from

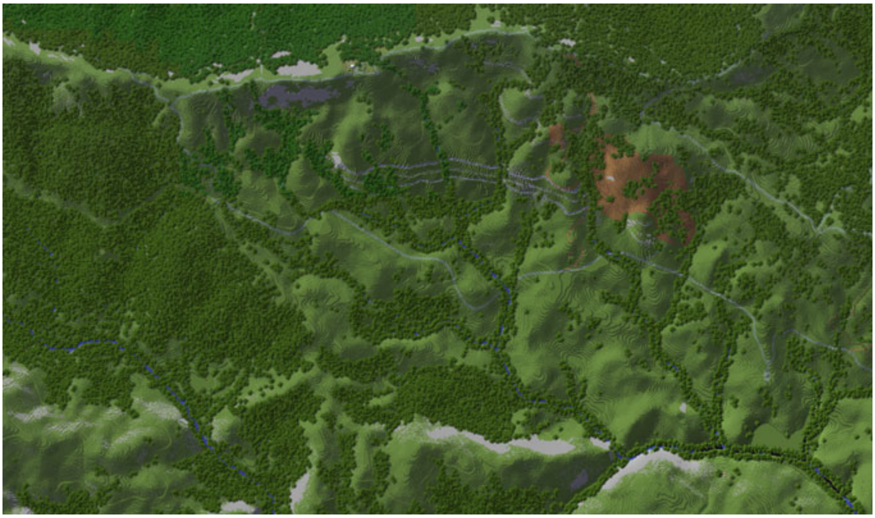

**Fig. 30.6** Vegetation layer placed along the rivers

0.3 to 1 was considered as a tree cover. The hydrology was used to locate the riparian forests along the streams (Fig. 30.6). The resultant Minecraft world was further processed with the help of WorldPainter and MCEdit software.

WorldPainter (Pepsoft 2019) is a free software that enables editing Minecraft worlds. We used WorldPainter to edit and manipulate vegetation layers, assigning specific cover pre-defined in FME. We applied the same approach for the underground geology. It was represented by subangular layers of different blocks representing real lithologies. We based it on a geological map of the area to recreate the dive and rock layer sequence. This step was implemented using underground layer manipulation tool in WorldPainter.

MCEdit consists of an application capable of accessing worlds created in Minecraft, making it possible to edit components within the game environment, such as inserting or removing objects/constructions (MCEdit 2019). We included historic buildings and other structures in a repository map, built individually based on pictures and real-world location (Fig. 30.7). These features were important to the game-concept implementation, composing the landmark of Ouro Preto Ridge as nodal points.

With the main nodal points arranged along the Ouro Preto ridge landmark, we were able to elaborate the game-concept based on it. In the next section we explain how the environmental storytelling (Jenkins 2004) was implemented from the realistic represented landscape in Minecraft.

**Fig. 30.7** Buildings repository (left) and buildings placed on topographic data in Minecraft

### *30.4.3 Implementation of the Game Mechanics in Minecraft*

The game concept as presented in Fig. 30.2 was implemented in Minecraft. Minecraft uses building blocks as one of its core mechanics. The characters in Minecraft were implemented as non-playable characters (NPC) as objects. The game was implemented in two different modes. In the first mode (red area on Fig. 30.2), the game runs in Adventure Mode. In this mode the player can interact with non-playable characters but cannot break or place any block in the game. In the second mode (blue area on Fig. 30.2) the game changes to Survival Mode in which the player can interact with blocks and is able to place and extract materials from the environment.

Minecraft has intrinsic mechanics that supports the implementation of the game mechanics. The command blocks are an effective way to assign a rule to a specific task. In GeoMinasCraft, we used command blocks to summon spiders inside one of the gold mines. This asset made it possible to include an additional challenge in the game. We used six modifications (mods) to implement the game concept (Table 30.2). Two related to the insertion of mechanics that directly support the game concept (Custom NPCs, Journey Map) and four related to aesthetics improvements (Dynamic Surroundings, Better Foliage, Decocraft, Tree Chopper, OptiFine).

Custom NPCs enables to create interactive characters with roles and dialogues. We used this mod to implement the three quests. They also offer the insertion of sensor blocks, which creates a radius of influence that detects when the player passes close to it. They were used in the last quest of the game in which the player had to find a suitable place to build a visitor center. Sensor blocks were allocated in three different spots within the park borders as marked in Fig. 30.8. The player is invited to explore these places based on the previous information provided to her by NPCs. While exploring the places the player also learns about the landscape and the risks associated with it.

The mod JourneyMap enabled us to include marking points, coordinate system and navigation in a mini map (Fig. 30.9). This mod provided tools with which we inserted the direction orientations from the dialogs. It also enabled us to produce a series of points of interest on the map which assist the player in spatial navigation during the landscape exploration.

**Table 30.2** Modifications utilized to implement game mechanics and aesthetics in GeoMinasCraft

| Name | Creator | Functionality/Mechanics |
|---|---|---|
| Custom NPCs | Noppes | It features tools to create NPCs and change their health/strength/weapons/skin and AI |
| JourneyMap | techbrew and Mysticdrew | Maps Minecraft world in real-time as the player explore. Allows to visualize the map in a web browser or in-game as a Minimap or full-screen |
| Decocraft | Razzleberry Fox | Adds in over 3000 decorations in Minecraft world |
| Better Foliage | octarine_noise | Improves how vegetation looks |
| Dynamic Surroundings | OreCruncher | Alters the player's visual and audible experience in Minecraft and does not alter game mechanics |
| Tree Chopper | MrDuchy | Allows players chop down whole trees by breaking the bottom log block |
| OptiFine | sp614x | Allows Minecraft to run faster and look better with full support for HD textures and many configuration options |

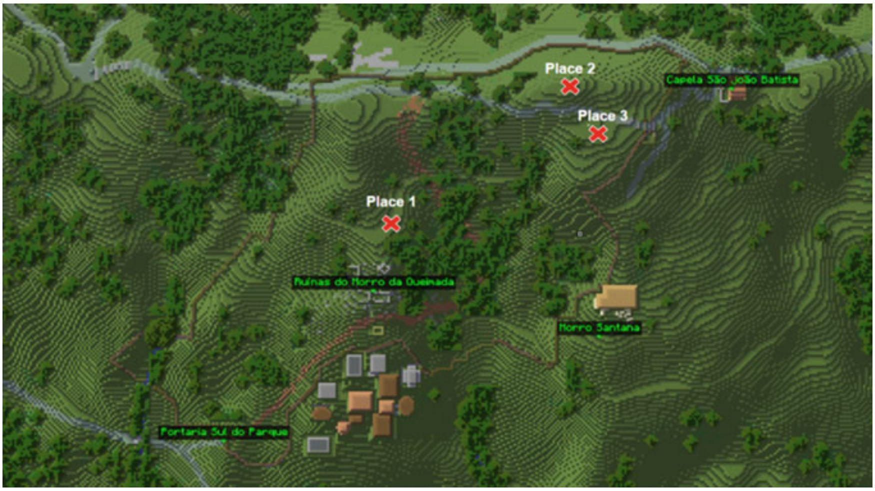


**Fig. 30.8** Location-based task—suitable spots to build a visitor center suggested by the NPC (sensor blocks represented by red crosses) and nodal points marked in the mini map in green (Journey Map)

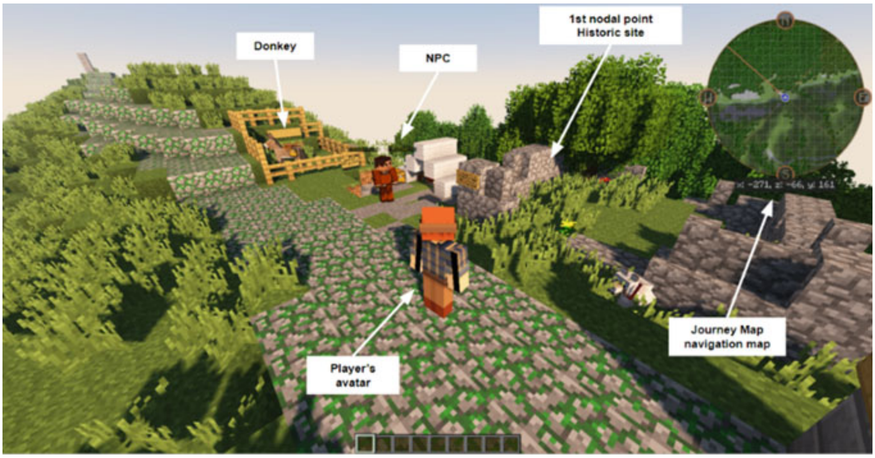


**Fig. 30.9** Third-person perspective of the game environment

## 30.5 GeoMinasCraft Prototype I: Testing the User's Interface

At this stage, the game can be tested by participants playing various versions of the prototype, giving constant feedback to improve the game experience. Figure 30.10 shows the continued process of prototyping, playtesting, and assessment. After the first implementation of the GeoMinasCraft (Prototype I) we gained results that helped us to improve the first prototype. Sections below explain the testing experience and the improvements of the first prototype.

**Goal**: The main goal was to test the currently implemented mechanics of the game. The focus was on understanding how difficult or easy the players find it to navigate in the implemented Minecraft game. The goal of this phase was to refine the prototype after each playtest and get feedback from the players with different backgrounds.

**Participants**: We invited grad students from the College of Design, at Iowa State University, U.S., to participate as volunteers in the study. Nine volunteers participate in the playtest. All of them were graduate students originally from the following countries: United States of America, Togo, South Korea, Honduras, Japan, and Brazil. The average age of the volunteers was 23 years old, with the oldest participant being

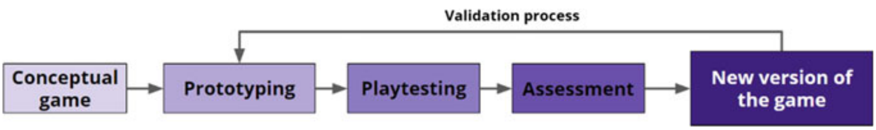


**Fig. 30.10** Minecraft landscape exploration game development process Adapted from Fullerton (2014)

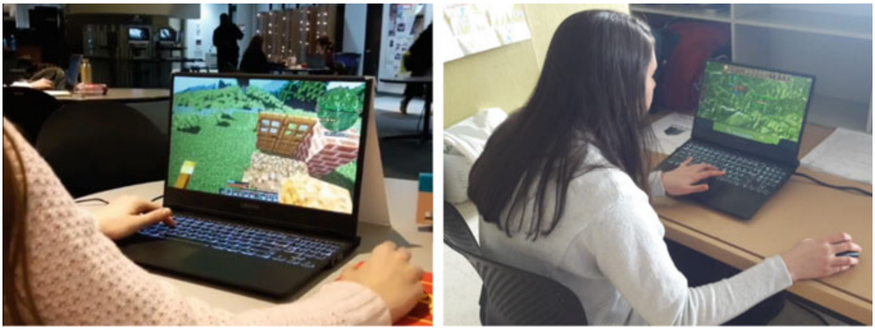

**Fig. 30.11** Participants testing GeoMinasCraft prototypes

43 years old and the youngest being 17 years old. Figure 30.11 shows participants testing the first prototype of the game at ISU.

**Procedures**: We explained the aim of the game and the research. For those who have never played Minecraft, we demonstrated the basic commands and ways to interact with the game through the mouse and keyboard. Videos were recorded with the previous permission of the participants. We recorded their moves with the mouse and their reactions to the features implemented in the game. We took notes while each participant was playtesting. We notified specific reactions, comments made by the volunteer player, and the elements that had to be fixed to solve glitches.

**Materials**: We had one laptop available with the game installed and ready to be play-tested. Questionnaires were printed in English with a blank page to be filled with comments. The questionnaire consisted of 10 questions; 3 for each basic quest in the game and one extra question related to the player's profile taken from Bartle (2005). Likert scale (1 to 5) was used to indicate the difficulty level experienced by the player performing the task. The questionnaire consisted of the following questions:

**Task 1**—Explore gold mining ruins—Walk through the ruins and read the signs

1. How easy was it to use keyboard and mouse to play?
2. How easy was to navigate using the mini map?
3. How helpful was to use a donkey to explore?

**Task 2**—Talk to Tereza, the archeologist—Help her to gather minerals samples

4. How difficult was it to find the hidden rocks and minerals?
5. How much did you like to fight a giant spider?
6. How much did you like to know more the geology and history?

**Task 3**—Build a visitor's center—Build a visitor's center for the Park with quest reward

7. How difficult was it to find the three places?
8. Did the Park Ranger provide enough information to you to find the three good places to build?
9. How difficult was to place blocks?

**Extra Question**

10. How much do you consider yourself a/an?

**Explorer**: Not much 1 2 3 4 5 Very much
**Achiever**: Not much 1 2 3 4 5 Very much
**Killer**: Not much 1 2 3 4 5 Very much
**Socializer**: Not much 1 2 3 4 5 Very much

The last question was designed based on Bartle's (1996, 2005) player type: *Achievers* like interacting on the world; *Explorers* like interacting with the world; *Socializers* like interacting with other players; *Killers* like acting on other players. In this sense, we could track what type of interaction would be more interesting after the playtest.

The playtest consisted of three main tasks.

**Task 1**. This task asked the player to explore the navigation in the implemented game using the mouse and keyboard commands. The players were instructed to walk through the ruins and read the signs presented to them in the game. One of the resources we inserted in the game was a donkey. Its function was to help players to move faster in the game environment.

**Task 2**. This task required the players to talk to the non-player character called Theresa. She is an archeologist. The players had to find minerals and help her to collect them.

**Task 3**. The player was asked to talk to the Park Ranger and find and explore three places on which the new visitors' center could be build. Players could build anywhere on the landscape, considering information previously provided by NPCs. With this task we were able to use the game to collect data from player's interaction with the virtual environment. It supported analysis regarding spatial assertiveness and difficulties in placing blocks.

## 30.6 GeoMinasCraft: Results and Reflections on Testing

### *30.6.1 Summary of the Main Testing Results*

The first task was intentionally designed as an introductory, rather easy task. The players were instructed to walk through the ruins and read the signs presented to them in the game. We can observe that the players felt comfortable with the controls, assigning 4 in a range of 5, in average, as well as reported that JourneyMap mod was helpful to explore the landscape. By the answers provided, most of the participants considered the donkey helpful for the accomplishment of the exploration task (Fig. 30.12).

For the second task, most of the participants indicated that to find the hidden objects was easy. They very much liked to fight the giant spider and enjoyed learning about geology and history (Fig. 30.12).

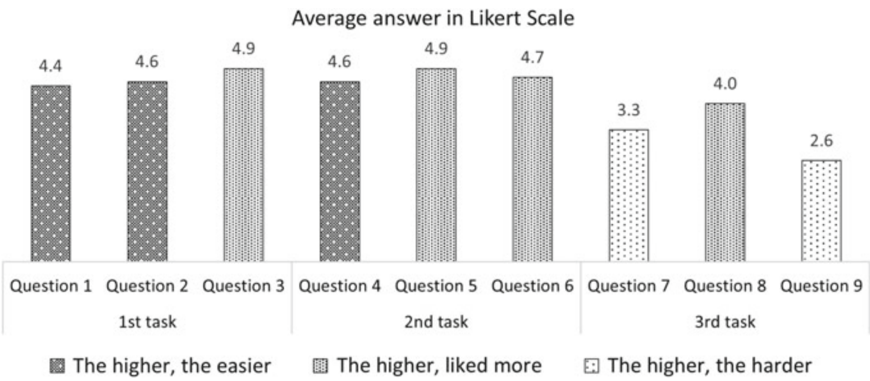


**Fig. 30.12** Answers from the experience with the three in game tasks

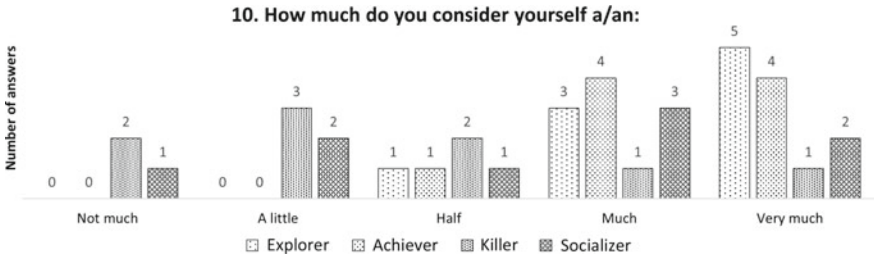


**Fig. 30.13** Answers to the extra question

The third task was perceived as very demanding by the participants/players. Information provided to them by the Park Ranger was perceived as useful and helped them to finish the task.

They experienced the task of finding the three suitable places within park borders challenging. Placing blocks in the game environment was also experienced challenging and rather difficult. The participants without previous experience in Minecraft reported substantial difficulties trying to accomplish this task (Fig. 30.12).

The extra question focused on the players' type. Most of the players consider themselves as explorers and achievers followed by socializers and killers (Fig. 30.13). They demonstrated a strong preference for exploring the game environment and accomplishing tasks introduced to them in the game. Fighting monsters were less preferable to them.

## *30.6.2 Reflections and Lessons Learned*

The results gained with this testing can be useful to other researchers and developers of serious games. We noticed substantial differences between players with previous experience playing Minecraft games in contrast to those that have never played a game in this game environment. Players with previous experience with Minecraft performed better knowing how to use mouse and keyboard. They struggle less in more complex tasks, such as for example those that required building objects. In our case they were challenged by the task of building a visitors' center.

The testing results showed that exploration is a core game mechanic in Minecraft. Minecraft as the game environment very well supports explorations and explorers and achievers play styles. We expanded it in the next prototype of the game by increasing the nodal points players must visit to achieve the main goal. In this way we added some additional challenges in the gameplay.

Short videos were recorded in specific parts of the playtest for each player. We focused particularly on those that were able to capture the reactions of players when they encountered a challenge. Especially challenging was to be able to kill the giant spider or to move and use the building blocks. Some of the players commented about the prototype when playing, sometimes reacting with surprise, or getting upset by discovering that they should walk through the map to achieve tasks. This process was important as it enabled us to collect insights for further development of the game.

Some players commented that it was fun to play the game prototype, and the environment was challenging and thought provoking. Since none of them knew the City of Ouro Preto, many of them felt invited to visit the city.

The method we adopted to evaluate the game demonstrate some limitations. Structured questionnaires are an easy way to collect data. At the same time, they are limited as they specify the type of answer one can get from the players. The number of players also was not significant enough to perform statistical analysis.

The diversity of backgrounds and age range of our participants/players were a valuable characteristic. It gave us a variety of responses to the game. Analyzing according to the age difference, we were able to observe the game difficulty and how it affected the players' experience of Minecraft. Older participants knew less about Minecraft, and the young ones were used to learn about it on social media or even playing it.

We made some additional changes in the game prototype. We inserted more signs along the path players should walk through. It was requested by players, as well perceived when some of the players got lost on the exploration route. The vegetation was edited in the game to make it look more attractive and at the same time more challenging. When transforming vegetation layer to 3D models of trees, some of the trees were blocking the roads. We improved this part and removed the blocks.

## 30.7 Conclusions

We explored how to represent realistic landscapes in Minecraft and how to develop a serious geogame that enables the player to explore the represented landscapes and learn about the topography, geography, and the historic buildings. This is the first step in our explorations of this diverse and promising game environment. In this chapter we summarize our technical approach used to represent geodiversity by using spatial data imported into the game environment. This chapter summarizes the main techniques and software used for this geographical visualization.

The option of applying a vertical exaggeration in the topographic data was relevant for the visualization of Ouro Preto Ridge as a core landmark in the territory. Representing the landscape in a 1:5 scale made it possible to emulate the mountainous areas like Ouro Preto region. This approach came with constraints on representing urban areas realistically. Although it increases the possibilities of geographical visualization of large areas in Minecraft.

Playtesting the prototype enabled us to assess the game mechanics, the visualizations presented to the players and their interactions with the user interface. We were able to understand the game potential and flaws in representing landscape. It also helped to observe players' struggles during the playtest.

The implementation of GeoMinasCraft game can be replicated in different areas. The core mechanics supporting the explorer and achiever play style can stay the same. The module representing the landscape, or the city can be changed and replaced by another city. We are thinking about designing the geography of the game as a unique module that can be changed interchangeably with other visualizations representing other cities and/or landscapes.

Our work also, additionally, confirmed the usability of Minecraft game environment for testing, scientific explorations, and implementations of realistic landscapes. Further research can be developed on tracking player's intervention on landscape and architecture. The game supports stealth assessment, which can be combined with assessment techniques like biofeedback from eye-blinking frequency, eye-movement, heart frequency and others.

The next step of this research is to share the process of testing the second prototype in Minas Gerais, Brazil. The game is being developed to be played by local children from Ouro Preto city to understand how the game could affect their perception of local landscape values. Understanding their way to interpret and plan on the territory i.e., proposing a visitor center, will provide information to better recognize their values for the landscape. Also, it aims to reflect on its application as a pre-requisite for urban and landscape planning processes in geodiversity conservation areas in Brazil. Future research is needed to investigate serious geogames usefulness and applicability for digital inclusion of youth in accessing virtually geo-heritage in listed and non-listed sites.

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