Minecraft in Support of Teaching Sustainable Spatial Planning in Secondary Education

Lessons Learned from the Marker Wadden-Project

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Abstract: In this article, we have assessed the educational affordances of Minecraft to teach school children about sustainable spatial planning. Specifically, we carefully examined the expectations and experiences of the learners and the teachers of this digital game as an educational tool for spatial planning purposes. The results of this explorative study confirm the educational potential of Minecraft. However, connection problems and digital vandalism ('griefing') by other players may seriously hinder the learning process. Moreover, it is advised to start with traditional design materials (e.g., paper and pencil) before working in Minecraft, as learners may find it restricting to be able to build with rectangular blocks only.

1 INTRODUCTION

A lively debate exists on the affordances of digital game-based learning for education. Since the beginning of this century, a large body of research has emerged on the positive and negative aspects of using digital games for educational purposes (All et al., 2016; Arnab and Clarke, 2017; Bouvier et al., 2013; Boyle et al., 2016; Brom et al., 2016; De Grove and Van Looy, 2011; Favier and van der Schee, 2014). Although the employed research strategies variate profoundly, there is academic evidence that the employment of digital games may result in higher learning outcomes (Dankbaar and Saase, 2015; Girard et al., 2013). However, a large set of factors influence the effectiveness of these media during the whole learning process. As such, these aspects have to be taken into account carefully when using game technology in an educational context (Hamari et al., 2016; Perttula et al., 2017; Proulx et al., 2017).

This paper focusses on the teachers' and learners' attitudes towards Minecraft as an educational tool for creating sustainable spatial plans in secondary education. In 2015, the Spatial Information Laboratory (SPINlab) of the Vrije Universiteit Amsterdam partnered with the Dutch Road Authority (Rijkswaterstaat) to teach school children about the complexity of designing sustainable landscape plans. We aimed to assess whether Minecraft was an appropriate digital game to engage young learners with this topic in an appealing and challenging way. Accordingly, we aimed to answer the following research question: Is Minecraft an appropriate tool for teaching the fundamentals of sustainable spatial planning in secondary education? We tried to answer this question with the outcomes of a pre- and postquestionnaire and by interviewing the involved teachers.

2 BACKGROUND

2.1 Project Description

From 2015 onwards, SPINlab has investigated how Minecraft can help to teach sustainable spatial planning in high-school education. We chose Minecraft because of its unique 3D representation of the physical world, the possibility to implement official spatial data of the Kadaster (Dutch Ordnance Survey) to reconstruct

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urban and rural environments from the physical world, and the easy learning curve of this digital game. The immense popularity of this game and the ability to alter specific mechanisms through 'mods' and 'plugins' also contributed to our decision.

In a project-based assignment, the children of the Technasium in Lelystad (the Netherlands) were challenged by Rijkswaterstaat to develop sustainable spatial plans for the second phase of the Marker Wadden ('Marker islands') in Lake Markermeer. Together with the National Nature Conservation Agency (Natuurmonumenten) and the dredging company Boskalis N.V., Rijkswaterstaat aimed to improve the water quality and biodiversity of the Markermeer-lake by creating islands with silt from the bottom of the lake. The construction of the Houtribdijk in the 1950s from Enkhuizen to Lelystad had blocked the flow of silt to open sea, and as such, during the second half of the 20th century, the vegetation of Lake Markermeer was covered by a thick layer of mud. To restore the water quality and biodiversity, islands were created with this silt during phase one of the Marker Wadden-project between 2013 and 2015.

School children were asked to investigate the possibility to use the islands not only to enhance the ecological quality of the area but also to generate sustainable energy (e.g., solar, wind, water power) and/or to create places where people can recreate (e.g., a harbor and visitor center). For this, we reconstructed in Minecraft the complete Markermeer, the islands and the landscape objects that lay around this lake. This virtual environment functioned as the canvas that the school children could use for their three-dimensional spatial designs.

2.2 Minecraft

Minecraft is a so-called open world game, released in 2011 by the Swedish company Mojang. Two game modes are provided: survival and creative. The survival mode allows the player to roam in a borderless (open) world. The primary goal is to survive in an environment full of dangerous creatures by building a house and producing food. In the creative mode, on the other hand, players already have access to all the materials and tools, which allows them to build anything that they can imagine. This mode proves to be an excellent starting point to engage learners in sustainable spatial planning. Moreover, the multiplayer option allows players to work together on the assignment.

Location plays an important factor in Minecraft. The open world consists of different regions with their own (visual) characteristics, place identity, and ecosystems. To navigate in this virtual world, the player has to think in a three-dimensional way as it is possible to move freely in all kinds of directions. Reasoning about distances, directions, and movement fosters the spatial thinking process. The game stimulates school children to use their mental rotation skills to create, adjust, destroy and recreate entire landscapes and objects. As such, various scholars have argued that Minecraft can efficiently contribute to the development of the learners' geographical and spatial thinking capabilities (Mørch and Thomassen, 2016; Nebel et al., 2016; Nguyen and Rank, 2016; Scholten, 2017).

Four game characteristics of Minecraft prove to be very interesting for educational purposes. In the first place, the player can design entire landscapes with its unique architecture, flora, and fauna. Some players reconstruct existing places and objects, such as the Eiffel tower or Dam Square in Amsterdam; others create fantasy worlds with castles, dungeons, and dragons. An entire world can be created with the use of rectangular blocks.

These Lego-like blocks have their own characteristics and textures and represent the building materials of the physical world. With these blocks, players can, for example, transform "silt-blocks" into grass or stone. Or they can create buildings with various "wood- or stone-blocks". This high level of interactivity is a second game mechanism, which makes Minecraft attractive for educational purposes.

Thirdly, Minecraft stimulates players to work together on a specific building project. In particular, children find it very engaging to "meet" in the virtual Minecraft world and to chat about daily life, as well as to impress each other with their building skills and creations. As such, Minecraft is a safe environment, where young people can escape from reality.

Fourth, the massive popularity of Minecraft has resulted in the creation of numerous "mods" and "plugins" to change the game mechanics and appearance of the game in many ways. The large

Minecraft community is one of the reasons why this game, since its release in 2011, is still trendy among children.

Lastly, another advantage of Minecraft is its capability to load official GIS datasets into the game environment. Together with the GEO-ICT company, Geodan B.V. the SPINlab used a Python computer script to implement these spatial datasets into the game environment. Complete areas can be integrally loaded in Minecraft without the need to build everything manually. It was, therefore, possible to integrate the whole Netherlands in the Minecraft game environment.

Because of these characteristics, we posited that Minecraft is a suitable digital game to employ for an educational project on sustainable spatial planning.

3 METHODS AND PROCEDURE

3.1 Project Design and Planning

To explore the educational affordances of Minecraft, SPINlab, Rijkswaterstaat, and the dedicated teachers have worked together on a lesson plan and an instruction booklet. In July 2015, the case study and learning goals were formulated, and a schedule was created to highlight essential activities and (preliminary) project deliverables. Subsequently, the teachers worked on a more detailed lesson plan and hand-out. At the end of August, all three partners agreed on the final version of lesson plan and the learners' instruction booklet.

The following lesson goals were formulated for the Marker Wadden project:

The school children can:

1. explain in their own words which spatial data can help them in creating a sustainable spatial planning;
2. perform a multicriteria analysis to decide how the implementation of the functions energy or recreation can be combined with the function nature in the spatial design of the islands;
3. create a draft of their spatial plan on scale on paper. They can motivate their decisions and are capable of receiving feedback from classmates and domain experts from Rijkswaterstaat;
4. implement the gathered feedback in a new, three-dimensional version of the spatial design in Minecraft;
5. can present their final versions of their spatial designs in Minecraft.

The school children had to use spatial GIS data that was provided by SPINlab to assess the suitability of these islands for sustainable energy or recreation purposes. Because the Marker Wadden were initially created to enhance the water quality and biodiversity of the Markermeer, the energy or recreation plans may not interfere with the ecological aims of the islands. As such, before developing a detailed spatial plan, the school children had to perform a multicriteria analysis with the available spatial data first. Subsequently, a two-dimensional draft version of the spatial plan had to be created and presented. Finally, the school children were asked to implement the gathered feedback in a definite, three-dimensional design in Minecraft and present it to the domain experts of Rijkswaterstaat.

In September, at the beginning of the new school year, school children in the eighth grade of the pre-university education worked in groups of three or four on this assignment until the final presentation on 10 December 2015.

3.2 Research Design and Instruments

To successfully help the school children with a virtual representation of Lake Markermeer and phase one of the Marker Wadden in Minecraft, three members of the SPINlab were responsible for three different tasks: 1) project-management, 2) research and communication, 3) data and technical infrastructure. A Ph.D. candidate was responsible for the aims of the lesson plan, research design, measurements, and communication with the teachers. The project manager was responsible for the budget and communication with the software provider (Teacher Gaming – MinecraftEdu, see description in the following section). A data engineer was responsible for the installation of the MinecraftEdu client software on the school computers, the preparation and configuration of the Minecraft environment, and the

communication with the ICT department of the school (e.g. for configuring the firewall).

A quasi-experimental design was employed to measure the school children's expectations of and experience with Minecraft as a tool for sustainable spatial planning. After the instruction, school children were asked to answer two open questions on paper:

1. What are the advantages of Minecraft for creating a spatial plan for phase two of the Marker Wadden? Please explain your answer.
2. What are the disadvantages of Minecraft for creating a spatial plan for this project? Please explain your answer.

The same questions were posed to the school children at the end of the project.

Table 1: Quasi-experimental research design.

	September	December
Class	Pre-questionnaire	Post-questionnaire
A3B (12-15 year)	Expectations of Minecraft (*n=23*)	Experiences with Minecraft (*n*=23)

3.3 Materials and equipment

A modified version of Minecraft was used for this project: MinecraftEdu. MinecraftEdu has been developed by the Finnish company Teacher Gaming and is specially created for educational purposes. It allows teachers to adjust the server settings in an easy to use dashboard interface. They can, for example, disable natural disasters (lava) or the appearance of predators (wolves) to create a digital environment that is solely suitable for learning and spatial planning practices. Moreover, the teachers can use the dashboard to monitor the activities of their pupils and instruct them with in-game messages.

Besides a client and server MinecraftEdu license, Teacher Gaming also provided a service for hosting the servers. We chose this option for practical reasons.

The Markermeer in Minecraft was created from the following GIS datasets: elevation data (AHN2), land use data (TOP10NL), and building footprints (BAG). All these datasets are open data and cover the whole of the Netherlands.

Table 2: Total costs of the MinecraftEdu license and hosting for this project.

Service	Quantity	Unit price (in US dollars)
MinecraftEdu User License	23	$ 14
MinecraftEdu Server License	12	$ 41
MinecraftEdu Hosting (per month)	6	$ 30 x 4 months = $ 120
Total costs		$ 175,00

4 RESULTS AND DISCUSSION

4.1 Results

As stated above, we asked the school children two questions at the beginning of the project in September and the same two questions after presenting their final spatial plans for the Marker Wadden to Rijkswaterstaat in December.

To question 1, about the expected advantages of Minecraft for this project, the children responded that the ability to assess the spatial plan from different angles proved to be one of the key strengths of this digital game for this assignment. In the post-test questionnaire, the school children still argued that the ability to get a good overview of the design is one of the critical strengths of Minecraft. They also responded that the ability to work together on the project was one of the key strengths of Minecraft for this learning task.

To question 2, about the disadvantages of Minecraft, the school children responded in the pretest that the unrealistic representation of Minecraft of the physical environment might make it difficult to create a realistic spatial design wherein nature and energy or recreation is implemented. Also, the lack of causality and the simulation of natural effects is regarded as a limitation of using Minecraft for this assignment. After the project, the school children regarded the lack of these functionalities still as a limitation of Minecraft. However, more surprisingly, technical issues such as server crashes and digital vandalism by other players (‘griefing’) have been reported as the most important negative aspect of using Minecraft for educational purposes.

Overall, the teachers were highly positive about the options that Minecraft provided for teaching school children about sustainable spatial planning. The ability to walk and fly through a digital reconstruction of the physical world and the use of a 1-by-1 scale has been mentioned as two significant advantages of Minecraft. Moreover, the need to work together and to explain each other's design choices has also been regarded as a positive aspect of this digital game, because it fosters the reflective engagement of the learners. By explaining what one is doing and why the school children looked more aware of their choices and decision. The interactive, real-time world of Minecraft stimulates school children not only to build but also to communicate about the spatial planning process.

The teachers did witness however that a large group of school children relied heavily on their two-dimensional paper blueprints during the three-dimensional enhancement of their spatial design in Minecraft. In specific circumstances, the children preferred to draw lines on paper instead to build with blocks in Minecraft. This suggests that Minecraft should be used together with other educational materials (e.g., paper and pencil) to teach the principles of creating sustainable spatial plans effectively.

4.2 Discussion

The results of this study confirm the affordances of Minecraft for educational purposes. However, we have learned that some factors have to be taken into account to implement this digital game in an educational context efficiently.

In the first place, it is highly advised to use a reliable technical infrastructure. The connection should be very stable, and the preliminary Minecraft-designs have to be regularly back-upped.

Secondly, access to the Minecraft-servers should be restricted to individual school children to prevent digital vandalism (‘griefing’) by classmates. To our knowledge, Minecraft-servers cannot be protected with a password. A so-called white-list (a list with verified names) might be a solution for this matter.

Thirdly, it is crucial to regard Minecraft as a tool for spatial planning and not as a means to an end. Other educational materials, such as the use of paper and pencil are also beneficial for the design and learning process. Accordingly, we argue that Minecraft should be introduced when the children already have received feedback on the first version of their spatial plan. Minecraft can be used as a spatial design tool for translating this two-dimensional concept map into a three-dimensional, digital spatial design. Since thinking in a three-dimensional perspective can be challenging, it is helpful if they already have a (general) idea about the spatial plan they want to create.

Future research of the SPINlab on Minecraft will focus on the affective and cognitive impact of this digital game in secondary education. In an experimental research design, we will try to assess to what extent Minecraft fosters the knowledge acquisition of school children and how this game enhances the learners' motivational and cognitive engagement. Accordingly, we aim to contribute to the scientific debate about the effectiveness of digital games in general, and Minecraft in particular, for teaching sustainable spatial planning.

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APPENDIX

Figure 1.

Figure 2.

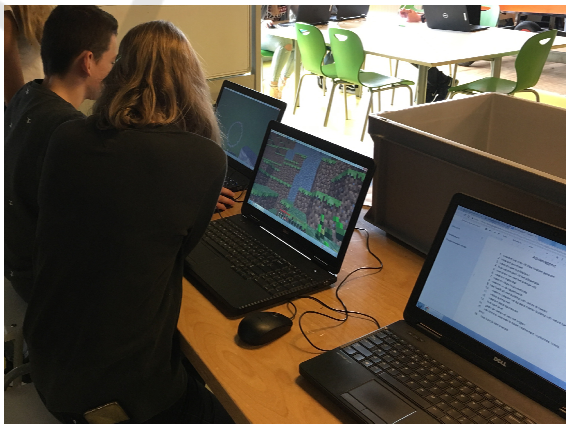

Figure 3.

Figure 1 and 2: School children's impression of phase two of the Marker Wadden project: room for nature and recreation. Figure 3: Working together on the three dimensional spatial design in Minecraft.