The Concept and Development of a Serious Game „Alter Eco" as Part of Creating a Digital Twin of a Smart City

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Abstract. An essential way to lifelong learning in the modern information society is using ICT, geoinformation, and the concept of the so-called serious games, as well as gamification mechanisms. The „Smart City Alter Eco" game is a solution that not only facilitates social education for sustainable development but is also part of creating a so-called digital twin of a smart city. The authors propose an approach that enables creating a virtual model of a city, which reflects spatial, economic, social, and legal relations, as well as testing various versions of the city's development. The objective of the game is not as much creating an operative biogas plant but making it an attractive solution to the environmental, economic, and social problems of the town of Żuromin in central Poland.

Keywords: Serious game · Gamification · Digital twin · Smart city · Sustainable development · Geoinformation · Information society · Geoparticipation

1 Introduction

For the modern information society moulded in the era of civilisational transformation associated with the spread of IT, games and gamification not only constitute a platform for virtual entertainment, but are, or perhaps may become, a tool for responsible and participatory shaping of the surrounding space. Sustainable development and shaping of the so-called smart cities [1, 2] by their inhabitants require the ability to process available information (including spatial data) and the needs or expectations of the local community, as well as the extraction and use of the acquired knowledge of those participating in the creation of an information society. One of the most effective ways to educate society on sustainable development is to utilise the techniques of gamification and the so-called serious games [3–7].

The primary purpose for creating serious games is not merely entertainment; "serious games" help the players in obtaining, developing and consolidating specific skills, as well as problem-solving [8].

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A variety of areas [9–15] uses serious games and serious games analytics [16–20]. The authors of this article aim to use serious games in the participative process of shaping a smart city, the development of (geo)information society, as well as solving complex social, economic, and environmental problems. Such a goal stems from the Warsaw University of Technology's implementation of the Ministry of Investment and Economic Development's project within the "Human Smart City" program. The project is entitled "Increasing the participation of residents of Żuromin in the process of managing, environmental monitoring, and creating a vision for the town's development by stimulating social geoparticipation." It is carried out by an interdisciplinary scientific team that supports the authorities and the local community of Żuromin – a town and commune located in central Poland, around 100 km north of Warsaw.

2 Problem Definition and Research Area

The crux of the problem of creating and developing a smart city in Żuromin lies in the residents' low level of engagement in the process of co-deciding about the town's development, and their low activity in social consultations, civic shaping of the spatial order or responsibility for the environment. Żuromin's specific problem is an inconvenient neighbourhood in the form of a massive number of pig and poultry farms in its immediate vicinity. Around this town with a population of 10 000, there is the largest poultry "basin" in Poland, with annual production exceeding 20 million chickens and 600 000 pigs. Such intensive agricultural production condensed within a few kilometres around Żuromin creates an extremely offensive odour. Standards for the concentration of substances, such as sulphur compounds, nitrogen compounds, and mercaptans, are far exceeded in this area. An additional problem lies in the excessive fertilisation of the soil with liquid manure, which degrades the soil and increases the odour offensiveness. This process also results in social conflicts between agricultural producers, residents, and town authorities; the local community accuses the authorities of being passive towards environmental degradation.

The construction of a biogas plant may solve this problem. It would also enable advanced processing of agricultural production waste, as well as reduce the odour and soil degradation, enable the generation of significant amounts of energy, and the commercialisation of the project. According to the authors, developing and popularising a serious game and running a social campaign, which shows that building a biogas plant would be beneficial for all the parties, may not only be an extremely innovative, but also an effective means of solving this problem.

3 Concept and Test Implementation of the „Smart City Alter Eco" Game

What is crucial in solving the problems of Żuromin is the issue of social education on sustainable development. The inhabitants of the commune (about 15 000 people), owners of poultry and pig farms (several hundred people), and town authorities (dozens of officials) should be made aware that only joint actions to shape a smart city may

bring the desired results. The construction of a biogas plant, in which odorous waste from agricultural production will be processed, may solve environmental, economic, and social problems. However, the issue of the location of the biogas plant, its power, funding sources, environmental effects and, above all, the sense behind its construction – have all sparked controversy in the town. The authors believe that the practical solution to this problem is creating a so-called digital twin of the town of Żuromin and testing different variants of its development. An excellent tool for solving this problem is building a virtual model of the town to develop a serious game so that a person may play as town authorities, agricultural producers or residents. This game would also enable virtual cooperation of all the parties and help them realise that cooperation is a win-win solution.

To develop a prototype version of the „Smart City Alter Eco" game, a tool environment of the engine of the strategic and economic computer game "Cities: Skylines" (based on the modified version of Unity3D) was used in cooperation with the game's producers from Paradox Interactive company. Using this engine is intentional: the open programming interface in "Cities: Skylines" uses C# language; therefore, it is possible to modify and develop the game's basic functionalities. The tool environment of "Cities: Skylines" enables using the Unity – UnityScripting API's programming interface, as well as modifying the content of maps, objects, rules, and scenarios for the development of a virtual town by using Map Editor, Theme Editor, Asset Editor, and Scenario Editor. The following are the underlying conceptual assumptions of the „Smart City Alter Eco" game:

- The application should display enough information about the commune so that users are able to find their place of residence and the main facilities in the town of Żuromin. Thanks to the engine from "Cities: Skylines" and 3D models of buildings, a digital twin called Żuromina was developed, where every object has its digital equivalent in the game.
- The application should ensure that the functions of particular buildings are recognised at first glance, e.g. distinguishing residential structures from industrial installations. This means that the 3D model should have contrasting textures in different positions so that a residential building is different from an office or a farm.
- Without any loss of efficiency, users should be able to zoom out on the entire municipality or to bring it closer to focus on a specific object. The view at the maximum close-up does not have to be very detailed, but it is necessary that at the maximum distance, one can still find a place, focus on it and approach it. It is permissible that only a few terrain elements are seen at maximum distances.
- All farms in the commune are marked on the model. Clicking on a farm brings up a window with available information on the farm, such as its size, the number of farm animals, and the number of generated pollutants.
- When users locate a biogas plant in the commune, the "connect", or "disconnect" button becomes available. Pressing the button enables or disables the use of a biogas plant by a given farm. The statistics of a farm change when it "connects" to the biogas plant. Connecting a farm to a biogas plant may require additional data, such as the cost of waste collection and transport, energy production profits, as well as the positive public perception by the residents of the commune.

- What is crucial to the effectiveness of the game is the visualisation of the environmental effects of building a biogas plant. The devised game enables the visualisation of two types of pollution: soil contamination and air pollution in the form of the odour. Connecting to a biogas plant causes the decrease of the level of air pollution (fast) and soil (much slower) in a given area of the town and commune.
- Users may place exactly one biogas plant in the commune; it cannot be located on a farm or in the town of Żuromin. Its location may influence the results of the simulation, mainly the estimation of the costs of waste transport.
- In the game, there are several variants of financing the biogas plant (commune investment, European Union funds, private investment, public-private partnership), but users may select and implement only one of the options in a given game. Naturally, the power and efficiency of the biogas plant can be modified during the game as subsequent farms are connected. The economic and social effects of making decisions are visualised on a map and in the form of a set of information tables indicating costs, profits, savings, environmental changes, and so on.
- Pollutants are assigned to a specific farm. In a given point of the town or commune, pollution comes from many farms. When it happens, the game engine and a proprietary spatial interpolation algorithm, which uses the GIS calculation engine, estimates how much pollution comes from which farm. When users switch the farm over to the use of a biogas plant, the change in the environmental impact becomes immediately visible in the digital view of the town.

4 Summary

According to the authors, using clear rules and the mechanics of gamification may enable large-scale public consultations, but – above all – may also contribute to the awareness of the social consequences of actions, and, indirectly, to the development of a knowledge- and morality-based open information society. There seems to be an interesting parallel [21] between the development of technology (including the use of games in the educational process), the emergence of an information society, and the formation of an open society defined by Karl Popper in 1945; a society characterised by a balance of proponents of various historicist theories [22]. Social participation for sustainable development may constitute an essential element of the public discourse in an information society (implemented, e.g., through properly built gamification tools), understood as a free exchange of opinions on shaping the surrounding space.

References

1. BSI Group: PAS 181 Smart city framework. https://www.bsigroup.com/en-GB/smart-cities/Smart-Cities-Standards-and-Publication/PAS-181-smart-cities-framework
2. Manville, C.: Mapping Smart Cities in the EU (2014)
3. Kapp, K.M.: The Gamification of Learning and Instruction: Game-Based Methods and Strategies for Training and Education, 1st edn., p. 336. Pfeiffer, San Francisco (2012)
4. Kapp, K.: The Gamification of Learning and Instruction. Pfeiffer/Wiley (2012)

5. Abt, C.: Serious Games. University Press of America (1970)
6. Aldrich, C.: The Complete Guide to Simulations and Serious Games. Pfeiffer/Wiley (2009)
7. Bartle, R.: Designing Virtual Worlds. New Riders (2003)
8. Loh, C.S., Sheng, Y., Ifenthaler, D. (eds.): Serious Games Analytics. AGL. Springer, Cham (2015). https://doi.org/10.1007/978-3-319-05834-4
9. Ifenthaler, D., Eseryel, D., Ge, X.: Assessment in Game-Based Learning. Springer, Heidelberg (2012). https://doi.org/10.1007/978-1-4614-3546-4
10. BankersLab: A smart guide to serious gaming (2013). http://bankerslab.com/blogposts/a-smart-guide-to-serious-gaming-part-1/
11. Arnab, S., et al.: Mapping learning and game mechanics for serious games analysis. Br. J. Educ. Technol. **46**(2), 391–411 (2015). https://doi.org/10.1111/bjet.12113
12. Carvalho, M.B.: Serious games for learning: a model and a reference architecture for efficient game development. Technical report (2017)
13. Bogost, I.: Persuasive Games. MIT Press, Cambridge (2007)
14. Gee, J.P.: Good Video Games + Good Learning, pp. 18–19. Peter Lang, New York (2007)
15. Ifenthaler, D.: Learning analytics. In: Spector, J.M. (ed.) The SAGE Encyclopedia of Educational Technology. Sage, Thousand Oaks (2015)
16. Canossa, A., Seif El-Nasr, M., Drachen, A.: Benefits of game analytics: stakeholders, contexts and domains. In: Seif El-Nasr, M., Drachen, A., Canossa, A. (eds.) game analytics, pp. 41–52. Springer, London (2013). https://doi.org/10.1007/978-1-4471-4769-5_3
17. Kim, T.W.: Gamification ethics: exploitation and manipulation. Published in Proceedings of the ACM SIGCHI Gamifying Research Workshop (2015)
18. Bellotti, F., Kapralos, B., Lec, K.. Moreno-Ger, P., Berta, R.: Assessment in and of serious games: an overview. In: Advances in Human-Computer Interaction (2013). https://doi.org/10.1155/2013/136864
19. Carvalho, M.B., et al.: An activity theory-based model for serious games analysis and conceptual design. Comput. Educ. **87**, 166–181 (2015)
20. Olszewski, R., Pałka, P., Turek, A.: Solving smart city transport problems by designing carpooling gamification schemes with multi-agent systems: the case of the so-called "Mordor of Warsaw". Sensors **18**, 1–25 (2018). https://doi.org/10.3390/s18010141
21. Olszewski, R., Wieszaczewska, A.: The application of modern geoinformation technologies in social geoparticipation. In: Gotlib, D., Olszewski, R. (eds.) Smart City. Spatial Information in Smart Cities Management. PWN, Warszawa (2016)
22. Popper, K.: The Open Society and Its Enemies. Complete, 5th edn., vol. I–II (1962). Revised (1966)