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Poplin, Alenka; Andrade, Bruno; de Sena, Ítalo

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Let's discuss our city! Engaging youth in the co-creation of living environments with digital serious geogames and gamified storytelling

Alenka Poplin
Iowa State University, USA

Bruno de Andrade
Delft University of Technology, The Netherlands

Ítalo de Sena
Masaryk University, Brno, Czechia

Abstract

This article concentrates on ways in which novel playful technologies can engage youth in co-creation of living environments. The presented study focuses on five selected prototypes of serious digital geogames and gamified storytelling that were developed specifically for younger generations of users. The analysis concentrates on reviewing their goals, game story, outcomes, and the results of testing serious digital geogames prototypes with youth. It leads to a set of identified urban planning engagement forms that can be well supported with the help of serious digital geogames. They include exploring landscapes, learning about places, learning about specific topics, re-constructing the past, envisioning the future, connecting with action projects, and communicating. The article concludes with the discussion of the main findings and perspectives for further research.

Keywords

Youth, engagement, geogames, gamified storytelling, urban planning

Introduction

Children and youth have long been neglected in participatory planning. They have not been considered as viable participants in urban planning (Crowley, 2015; Horelli, 2018) and represent marginalized groups of residents that often have very few opportunities for expressing their wishes,

Corresponding author:
Alenka Poplin, Department of Urban and Regional Planning, Iowa State University, Ames, IA 50014, USA.
Email: apoplin@iastate.edu

needs, and concerns to the planners. City officials rarely organize activities that are shaped to genuinely engage youth in co-creating the future of the places in which they live. Participation is also the least recognized of the "3Ps - provision, protection and participation" included in the UN Convention on the Rights of the Child (Sgritta, 1993). This article uses "youth" to include every one of the age from their birth to their 18th birthday (Cunningham, 1995). Additionally, there is no general practice established in urban planning to let youth climb "the ladder of participation" (Arnstein, 1969) to a level where adults and youth could cooperate discussing the future of the living environments on an equal basis (Hart, 1992). This is one of the indicators of where adults place youth in the society; instead of empowering them in contributing their perspectives, adults rather decide to neglect their views, perceptions, and needs in urban and rural spaces.

There are two main goals of this article. The first is to analyze implemented and tested serious digital geogames. The second goal is to analyze them in terms of engagement and summarize the main engagement forms that can be enabled by them. The selected digital prototypes include *GeoMinasCraft Game, Geodesign Card Game, FoodFinder: gamified storytelling, Fingalcraft* and *Tirolcraft*. The analysis concentrates on their goal, game story, outcomes, and the results of testing geogames prototypes with youth. The main result is a summary of engagement forms derived from the analysis of these games. In a combination with an urban planning process, they have the potential to become building blocks for a novel framework on how serious digital geogames can enhance urban planning processes of the future engaging youth. The article concludes with a discussion and further research directions.

Inclusion of youth in urban planning through serious digital geogames

Youth in urban planning

The idea of involving youth in urban planning is not new. However, not much has been done in this respect to set it up in practice and implement it in actual urban planning processes. "Children/Youth and participation" was a fairly popular theme of research in the 1970s, especially in English speaking countries (Ward, 1977; Moore, 1978). The topic emerged again in the 1990s with several case studies, but it mostly stayed in the domain of research bouncing off of the ideas and concepts. Fassbinder (1995) suggested that the classical, hierarchical, top-down organization of urban planning has become obsolete. "These paradigm shifts create, on the one hand, challenges for young people to learn and for schools to teach new environmental and argumentation skills. On the other hand, this is a challenge for research to come up with new methodological "tools," which will enable young people to take part in varying arenas of urban planning," (Horelli, 1997). After conducting experiments with children (between 7 and 12 years old) Horelli (1997) concluded that they are capable of dealing with a great variety of issues, concerning not only the school yard, but the neighborhood as a whole. They "tend to define local supportive structures multidimensionally and seem to express a rationality of care and responsibility" (Horelli, 1997).

Research already in the late 1990s indicated that "if the participation process is well-structured, children and young people show striking competence in the analysis of environmental problems as well as in the formulation of new ideas" (Horelli, 1997). Cherry (2011) observed that even though researchers tend to place youth in the center of community engagement, much of the engagement work is still done *for* youth rather than *with* youth. Youth are rarely included in decision-making at either the city or neighborhood level (Khanlou, 2008; Crowley, 2015; Keeffe and Andrews, 2015). This research aims at filling this gap and positively contributes to ideas on how youth can be engaged with the means that are potentially very close to them and well understood by them, for example, games. It concentrates more specifically on serious digital geogames for youth.

Development of serious digital geogames

Serious digital geogames are a novel research area. "Geo" inferred from Ancient Greek Γαῖα, a form of Γῆ *Gē*, Ge meaning "land" or "earth." It indicates the environment of these games with the focus on Earth or its parts. Serious games are games that are developed for more than just fun and entertainment (Michael and Chen, 2005). They are often implemented for specific real-world situations including simulations, training, learning, analysis of management and organizational structures, and others (Ritterfeld et al., 2009). Figure 1 shows the timeline with the main research and development hubs and illustrates some key achievements in the research filed of serious digital geogames. It only includes those that, according to our knowledge, substantially contributed to the research field of serious digital geogames.

The first known publications mentioning the notion of geogames were published in 2005 and 2006 by Schlieder and his team from the University of Bamberg (Schlieder et al., 2005, 2006). They worked on developing and implementing Location-Based Games (LBG) which they called geogames. LBGs make use of positioning technology (e.g. GPS) and integrate the player's position into the logics of a game. Players are actively and physically involved in the game environment. Their experience is usually combined with the visualization on a map presented on a mobile device (Schlieder et al., 2006). Geocashing is an example of a geogame. It is organized around the idea of hide and seek items called "geocaches" or "caches," which can be found in the physical environment with the help of a GPS receiver.

In 2012, Ahlqvist and his colleagues at The Ohio State University expanded this rather limited understanding of geogames to "all games that use real-world spatial information and are mediated by geographic information technology (GIS)". According to them, "A fundamental idea underlying the GeoGames approach is the focus on creating an online world that mirrors (c.f. Gelernter, 1991) authentic real-world geography, realized by a full range of GIS supported mapping and processing services" (Ahlqvist et al., 2012). The "mirroring" of the real world is an attempt to represent it realistically in the game environment. Figure 1 also indicates two main publications. The first one includes the first edited book titled *Geogames and Geoplay* edited by Ahlqvist and Schlieder (2018). The second one indicates the first edited journal published online with nine articles edited by Poplin and Schwartz (2020). The application areas of geogames include urban planning (De Andrade et al., 2020; Devisch, 2008; Devisch et al., 2016; Gordon and Manosevitch, 2010; Gordon and Schirra, 2012; Krek, 2008; Poplin, 2012, 2014, 2017, 2018; Poplin et al., 2017, 2018, 2021; Poplin and Vemuri, 2018), cultural heritage, geography (De Sena et al., 2018; De Sena and Moura, 2022), climate change (De Andrade, 2020) and geodesign (De Sena et al., 2021), and architecture (Poplin, 2020). The Rochester Institute of Technology added application areas in disaster management (Schwartz and Tomaszewski, 2021; Tomaszewski et al., 2018, 2020) and well-being. There are only a few attempts in research on serious digital geogames that concentrate on youth.

Research focus and methodology

This research aims to collect all known serious digital geogames for youth and analyze their usability in urban planning. It asks a fundamental question: "Are there any serious digital games implemented and tested with and for youth and which engagement processes may they support?"

The research methodology consists of the following steps: a) Select developed and implemented prototypes of serious digital geogames designed specifically for youth; b) analyze the selected geogames in terms of their goals, game story, testing with youth and outcomes; c) identify engagement forms that may be enabled and supported by serious digital geogames for youth; d) compile a summary of the research results; and e) conclude about the functions serious digital

geogames may be able to support in the process of engaging youth in urban planning processes (Figure 2).

The games appropriate for the comparison had to satisfy the following main criteria:

a. They have to be serious games, for example, developed to be used to solve real-world problems and not played just for fun.
b. They have to concentrate on an urban planning situation that is related to a real-world problem in the selected area.
c. They had to be developed specifically to engage youth in urban planning processes.

It was very difficult to find games that satisfy all these three criteria. Due to the difficulty of finding such geogames, this research concentrated on the games developed at the main serious digital geogames research and development hubs illustrated in Figure 1. In case new digital serious geogames for youth appear in the market or in research, they can be added to the list and researched further. Two of the analyzed geogames were the result of two PhD studies located in Brazil. Three of the games use Minecraft game environment due to its popularity among youth across continents. A simple statistic about the use of Minecraft reports that Minecraft generated $415 million in revenue in 2020, mobile revenue accounted for $110 million, over 130 million people play Minecraft once a

Figure 1. Geogames research and development timeline with the main hubs indicated.

Figure 2. Research methodology used for the research presented in this paper.

month (in 2020) and it has been sold in all formats over 200 million times (Curry, 2022). The next section introduces the selected geogames and describes them according to their goals, the main game story, testing with youth and outcomes (the Select and Analyze phases).

Digital serious GeoGames and gamified storytelling developed for youth

GeoMinasCraft game

Goal. The goal of the game is to encourage youth to learn about landscapes and explore their historic and cultural values. It takes the player to Ouro Preto, a historical UNESCO town in Minas Gerais, Brazil.

Game story. *GeoMinasCraft Game* is a single player exploratory adventure game implemented in the Minecraft environment. The player can travel through the landscape and communicate with the non-playable characters (NPCs) included in the game (Figure 3).

The player is invited to actively explore Ouro Preto's ridge geology and history, learn about the Gold Cycle period in Brazil, geological hazards and risks in the city, and conservation of this significant historic site. The incorporated quests make the game more challenging and exciting and include searching for gold and iron nuggets, fighting a spider, finding a suitable place for the visitors' center and others.

Playtest. Nine students from Iowa State University and one from the Federal University of São João del-Rei provided their initial feedback on the first prototype of the game. It enabled the researcher to validate the game-design, as well as to fix potential problems with the game mechanics. The final version of the game was then played by local youth from two different neighborhoods located in the Ouro Preto ridge hills (Figure 4).

Outcomes. After testing, the exploration route and dialogues with NPCs were redesigned. The youth from Ouro Preto reported that they gained knowledge about the landscape and historic preservation of the area. The NPCs created in the game were based on real people from the place which had a very positive effect on the local children playing the game. The location-specific design strengthen some of the bonds with already developed values of the landscape by recognizing places and people implemented in the game.

Figure 3. Teteco is an NPC based on the real park manager of Andorinhas State Park.

Figure 4. Youth playing GeoMinasCraft Game.

Geodesign card game

Goal. The goal of this game is to teach about cultural values, built environment and its heritage, and to enable the creation of scenarios for sustainable future development of the place based on identified cultural values.

Game story. The game takes the player to a rural village in the municipality of Santa Leopoldina, Espírito Santo, Brazil. The player can explore the built and natural environment, navigating with a virtual tool on a computer. It is a role-playing game and the player can choose to play a farmer, professor, doctor, mayor, merchant or community. The player can then propose, negotiate, and vote on design scenarios using photos presented in a 180° panorama photography style.

Playtest. The game was tested with 9–12-year–old youth from the village of Santa Leopoldina. In the first sessions, the youth explored the town in a virtual navigation setting made of a thematic map with icons representing the built heritage and areas of interest (Figure S1(a)) (De Andrade et al., 2020). In the follow-up session, the youth joined a role-playing game (Figure S1(b)).

Outcomes. Playing the game, the youth proposed more educational (language courses and higher and technical education), agricultural (diversifying the current production that relies mainly on ginger and banana), and public playful spaces in order for the village to become more self-sustainable. This showed that youth can think holistically about land use change.

Fingalcraft: Geodesign Minecraft game

Goal. This game enables envisioning the future of a town implemented in a Minecraft environment based on sustainability and cultural values.

Game story. Three locations in towns Portrane, Donabate, and Rush surrounding the Rogerstown Estuary in Fingal (Dublin, Ireland) were reconstructed and visualized in Minecraft. The goal was to enable a design of self-sustainable scenarios of at least one of the three locations. All areas have been facing environmental issues of coastal erosion and flooding due to climate change impacts.

Playtest. Youth between 9 and 12 years of age joined the online geodesign Minecraft game workshop. On the first day, they learned about the purpose of the workshop and how to create design proposals. On the next day, they presented their designs and discussed their proposals. At the end, the parents gave their feedback on the workshop potentials and challenges and their observations supporting the youth in the process.

Outcomes. Playing the game, children proposed new stations and railways that may enable a faster connection with Dublin city. They proposed biodiversity and green infrastructure to protect the Portrane Peninsula from coastal erosion and flooding, create a bird-watching preservation park (Figure 5), and an engineering structure to pump the water out of the Estuary. They also proposed public playful spaces on land and water. This process demonstrated that youth can think about complex problems such as climate change impacts and can come up with creative and reasonable solutions that aim at preserving and developing sustainable environment.

Tirolcraft

Goal. The main goal of this game was to enable the reconstruction of the past of a town Tirol through the Minecraft simulation game *Tirolcraft*, based on the heritage values that shaped the architecture of the place. The target group was youth between 4 and 11 years old.

Game story. A rural village in the Tirol district in the municipality of Santa Leopoldina, Espírito Santo, Brazil, was reconstructed as a Minecraft 3D gaming model (Figure 6). It enabled the players to reconstruct the past of this place. This game was an adaptation of the *Block by Block* (von Heland et al., 2015) and *Geocraft* (Scholten 2017) methodology used for youth engagement in architecture and urban design.

Playtest. Two subsequent experiments were conducted with the support of schoolteachers and incorporated into the pedagogical teaching structure in classes related to geography and history. The youth could either (re)produce the Tirolean built fabric as it stands or propose new architecture in response to agreeing or disagreeing with the design choices made by the previous generations (Figure S2).

Outcomes. The final designs suggested by the playing youth demonstrated the development of orientation-related skills and an increased knowledge of architectural history, urban planning and

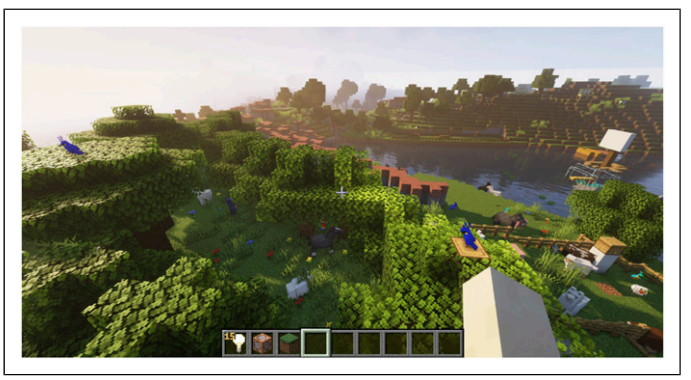

Figure 5. Proposed green walls and biodiversity park—bird-watching trails.

Figure 6. The final result of the 3D reconstruction of Tirol by children in Tirolcraft.

physical geography in the region. Using a small top-view map on the Minecraft screen they were able to locate their houses; correlate the map with the real landscape; align digital, real and mental mapping; comprehend basic cartographic principles such as metric proportion, scale, coordinate system, symbols and legends; and better understand the architecture (building materials, implementation, scale, color, typology) and the landscape (geomorphology, relief, soil, water resources, green areas, landscape typologies).

FoodFinder: gamified storytelling

Goal. The main goal of *FoodFinder* was to enable the exploration of food sources in the neighborhood using gamified online map-based approaches. The youth involved were Spanish speaking Latino minorities from three low-income neighborhoods in Des Moines, Iowa, USA.

Game story. The gamified storytelling engagement platform was developed with the help of online interactive maps implemented using geographic information systems (GIS). The storytelling happened in the process of designing and constructing data about food sources and sharing them with other players. The process was gamified with incentives for being the fastest in mapping and finding places, and rewards for sharing stories. The rewards were candies and fruits which initiated the discussion about healthy food.

Playtest. The play-testing was organized two times in a collaboration with the Girls and Boys Club. The youth was first introduced to paper maps which helped them to learn about different map scales, representations, colors and symbols. Introducing online maps inspired them to explore the area and to search for places. The search function in GIS was fun to use; the youth really enjoyed typing different place names and then observing the online interactive map finding these places. In the next step, the online interactive map was projected on the blackboard (Figure 7). The youth gathered around the map and talked about the food sources such as shops and restaurants. They marked them with pens on the blackboard with the projected map. Then the research team demonstrated how to create two new layers in ArcGIS Online using Map Notes (Figure S3). One of the layers represented the shops in which they bought food and the other one was created for the restaurants at which they ate. Throughout this process the youth learned how to read and navigate a map and how to create new data in ArcGIS Online. The created data about food sources was again projected on the blackboard and served as the basis for the second storytelling session about food sources.

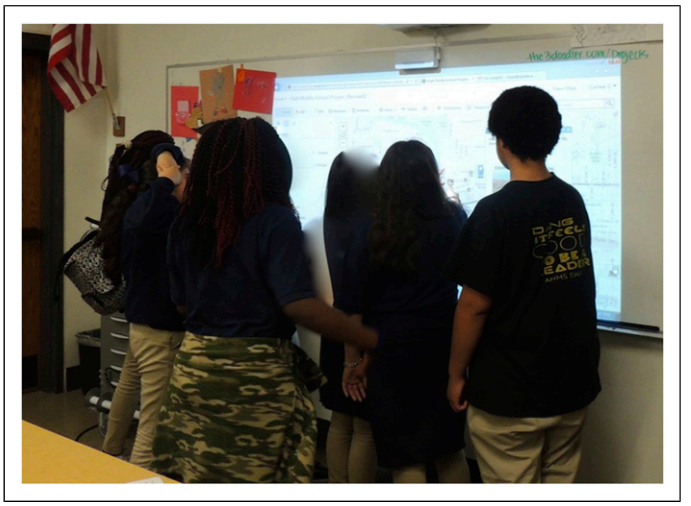

Figure 7. Youth using the projected online interactive map to discuss the sources of food (Copyright: Linda Schenk, ISU).

Outcomes. The experiment with online interactive maps encouraged spatial thinking and discussions about food. The youth realized that there was no access to healthy food in their neighborhoods. All the food available close to their homes was fast food and low quality, cheap food. They were very motivated to share their stories, explore paper maps and learn how to use interactive online maps. Additionally to that they initiated a local community garden, help revitalize the existing one, helped clean it and plant vegetables (Figure S4).

Engagement forms enabled by serious digital Geogames and their link to the action projects

The presented and analyzed serious digital geogames and gamified storytelling applications were developed to stimulate and inspire the digital and playful engagement of youth in urban planning. The main result of this analysis is summarized in Table 1 as a list of functions of an engagement process that can be enabled with the help of playful, game-based applications. After a careful study of the serious digital games in respect to the needs in urban planning processes, a list of functions was identified. They link the implementations in the analyzed games with the processes often used in urban planning. This result can potentially lead to a conceptual framework of Gamified Urban Planning for Youth which can correlate the functions and operations that can be implemented in game environments with those needed in the engagement of youth in urban planning processes.

The engagement forms identified based on the analysis of the serious digital geogames prototypes listed in the rows of Table 1 include exploring landscapes, envisioning places in the future, learning about places, learning about a specific topic, connecting with action projects, reconstructing the past, and communicating. They represent examples of possible processes that can be designed in a playful way and may be successfully used for youth engagement in urban planning. Five of these engagement forms, including exploring landscapes, learning about places, learning about a specific topic, connecting with action projects and communicating, were well supported by all of the analyzed serious digital geogame prototypes. This list (Table 1) demonstrates the versatility of serious digital geogames and their usability in engaging youth in urban

Table 1. Engagement forms enabled by the selected serious geogames for youth.

	Engagement form				
Geogames	GeoMinasCraft	Geodesign card game	FoodFinder: Gamified storytelling	Fingalcraft	Tirolcraft
Exploring landscapes	Exploring geodiversity, historic and cultural values of landscape	Exploring the main points of interest in the village	Exploring the area, its landmarks, and the sources of food	Exploring the landscape in order to find optimal locations to design	Exploring the landscape in order to find optimal locations to design
Learning about places	Dialogues with NPCs explaining about points of interest and remarkable historical sites	Learning about the points of interests and locating my own home	Learning about the neighborhoods and locations of the food supply and its quality	Learning about heritage values including ecological, economic, social, scientific and historic values	Learning about ecological, social and historic heritage values
Learning about specific topics	Brazilian gold cycle, geodiversity, mining heritage, geological risk	Negotiation and decision-making in urban development	Food stores and restaurants, food deserts, healthy food	Climate change and its impacts in coastal areas	History of the Tirol settlement and its relation to Austria
Reconstructing the past	Learning about the historical sites of this area, learning about mining				Reflecting over the past context and choosing the location to (re)design the town
Envisioning the future	Finding the best location for a new visitors' center and for a local archaeological park	Building a picture collage to represent the wishes and ideas for the future		Choosing the location to design new architectural buildings and urban infrastructure and facilities	
Communicating	Dialogs in the game, communication among players playing the game in pairs on one computer while controlling the avatar	Role-play and social interactions between children in order to play the game	Based on interactive online maps projected on a screen enabling communication in person	Multi-player game played online with the communication enabled via chat	Communicating in person, while one player is in charge of the digital designing using the laptop
Initiating action projects	Photography walks, geo-touristic trails, city's winter festival, historic and environmental conservation movements	The activity was added to the pedagogical curriculum of the local school	Revitalizing local community garden, planting in the community garden, meeting with parents at the community garden	The activity was a pilot project for youth engagement in final development plan 2023–2029	The activity was added in the pedagogical curriculum of the local school

planning processes in a playful way. We describe them more in detail in the continuation of this section.

Exploring landscapes

It is in the nature of serious geogames to offer tools to the player to be able to explore; all of the analyzed games offered this option. Exploration can happen in the form of clicking on the geographic elements and accessing the data stored in the GIS system (*FoodFinder*), it can be visual by virtual walking or riding a donkey through the landscapes (*Geodesign Card Game, FoodFinder, Fingalcraft, Tirolcraft*), or it can occur in the form of asking questions and communicating via dialogues with NPCs (*GeoMinasCraft*). Exploring can be interactive—interacting with the landscape and/or the implemented game characters—or passive by just observing the landscape, by traveling through it or just by playing the game.

Learning about places

Learning about places is fundamental for youth engagement in urban planning. It enables them to get to know the environment that is in the center of the engagement process. The players may substantially differ in their pre-knowledge of the discussed area. Some of them may live in this area and know it fairly well from the real world and others may see it for the first time visualized and represented in a geogame. It remains to be further researched how differently players play the game in all of these different pre-knowledge cases. Learning implemented in a geogame can be both active and passive. Active learning can be implemented as the ability to ask questions, communicate with the characters and/or implemented objects, navigate in the implemented environment or actively interact with this environment. Passive learning happens in every step of the game by just playing the game, navigating in the implemented game environment, and making decisions and strategizing on how to continue playing the game.

Learning about specific topics

The geogames analyzed in this paper include topics such as geodiversity, mining, history of places, slavery, golden cycle in Brazil, food deserts, food sources, healthy food, cultural heritage, heritage values including social, economic, scientific, and ecological values, architecture, and urban infrastructure. The list of specific topics is inexhaustible; geogames offer almost unlimited potential to address specific topics and to encourage critical thinking and educating oneself on these topics. Players' interactions with the game environment may increase their knowledge of these specific topics and enable them to explore them in depth.

Reconstructing the past

Two of the analyzed games included the option of reconstructing the past and learning from it. *Tirolcraft* enables to study the history of a place called Tirol, located in Brazil. The immigrants from the original Tirol located in Austria brought their language, food, and cultural traditions to Brazil. The player in *Tirolcraft* is encouraged to re-construct the past of this place and, in doing so, learn about its history and architectural styles. *GeoMinasCraft game* engages players in the exploration of underground gold mines, ruins, and aqueducts in Ouro Preto. At each of these sites, players can communicate with the implemented characters and retrieve information about the history of this

place, the conservation concerns, geotechnical risks, and the reasons for building houses on the top of ruins, and mines, particularly in the Gold Cycle period.

Envisioning the future

The process of envisioning the future represents a huge potential for future implementations of geogames and can be potential integrated in the geodesign framework introduced by Steinitz The analyzed geogames take a rather simplified approach in envisioning the future. They enable the player to search for suitable locations for the new visitors' center, the new archaeological park (*GeoMinasCraft*), and to introduce new architectural buildings and building infrastructure (*Fingalcraft*). Envisioning places of the future is limited by the ways in which it is implemented in the analyzed games. It is also a rather complex process that requires prior learning about the planned activities and involves creativity in thinking about possible future solutions.

Communicating

Communication is one of the central themes for all geogames. Communication can happen among the players, between the player and a game character, and between a player and an interactive map or even objects visualized in the game. In *GeoMinasCraft*, the player can communicate with the NPCs in the game, ask questions and explore their perspectives. In *FoodFinder*, the player can ask spatial questions and the GIS software will provide answers. An example of a question like that may be: Show me all locations of the supermarkets, farmers markets, healthy food markets or restaurants within a given area. The system is then able, based on the data stored, to provide responses to such questions. *Geodesign Card Game* includes communication among players while they are deciding about the future scenarios and discussing what would they like to see implemented in the future.

Connecting with action projects

Connecting engagement with action projects through which real-world changes are visible indicators of the impact the engagement process has had on the community. They intend to result in a positive change, an improvement in the life of those involved in the community. The action projects listed in connection with the analyzed geogames are remarkable. Some of the action projects were initiated during the time of the game-play, but the majority of them after the game-play. During the process of engagement with *FoodFinder*, the youth discussed food deserts and lack of healthy food in their neighborhoods. They then got involved in the revitalization of an abandoned community garden, cleaned the lot, and organized planting. Figure S5 shows the youth enthusiastically cleaning the garden. At the end, the community garden turned out to be a success and a pride for all involved. It empowered the youth to practice leadership and sovereignty and to contribute to positive changes in their living environment.

The game-based activities incorporated in the *Geodesing Card Game* and *Tirolcraft* were added as part of the curriculum in the local schools, which shows the impact they had on the pedagogy and content of the classes. The *Fingelkraft* game impacted the way youth were engaged in the Fingal Development Plan 2023–2029. In Ouro Preto, where the game *GeoMinasCraft* was placed, there is now an active movement for the conservation of the Serra de Ouro Preto centralized in Veloso's Mine. Because of the historic importance of this area, many action projects such as photography walks and geo-touristic trails were promoted to raise the awareness of the historic importance of this place. The *GeoMinasCraft* game was one of the initiatives with which they aimed to engage locals in the process of learning about the area's historic and environmental values.

Attractiveness of digital game–based environments

Digital game–based environments are attractive to the younger generations for many reasons. Learning novel technologies can be very motivating and stimulating for the youth. Using known game principles and environments from well-known games like Minecraft can additionally stimulate youth to play and get engaged. During testing of the *GeoMineCraft Game* it became clear that many of the involved youth had moderate or even extensive experience playing games in the Minecraft environment (De Andrade et al., 2020, de Sena et al., 2021). Because of that, they could quickly adapt to the environment and learn the new features of the geogame. Contrary to this, the majority of the youths who participated in the GIS-based experiment *FoodFinder* did not have any experience with online maps and very minor experience with paper maps. It seems that more learning and teaching about maps and online GIS-based tools would need to be involved in the case of GIS-based implementations for youth engagement. The youth was very motivated learning new computer skills and ways in which they could create and visualize data and interact with digital online maps.

Conclusions and further research

This research represents the first step toward a conceptual framework for the engagement of youth in urban planning with the help of serious digital geogames. It contributes to the discussions about the possible role serious digital geogames may play in transforming urban planning to become more inclusive, inviting and respectful toward youth. It builds on the recognition of the new young generations being digital natives (Prensky, 2012), using novel technologies from an early childhood and being able to quickly adopt them in their daily life.

The main result is the list of functions and engagement activities that can be implemented in serious digital geogames and can support the urban planning processes. The main value of this contribution is two-fold: 1. It demonstrated and summarizes serious digital geogames specifically developed for the engagement of youth in urban planning processes and 2. Demonstrates a clear link between serious digital geogames and their usability for the purpose of engaging youth in urban planning processes.

This paper overviews five selected game-based prototypes, their goals, game stories, main outcomes and the results of testing with youth. These implementations were well received by the youth involved in the process of testing, which demonstrates an untapped potential for this area of research and practice to substantially contribute to the ways in which youth could be engaged via novel, digital game-based applications. The selected applications serve as examples and cannot be considered as the final list of existing applications. Based on the analysis, a set of seven core participatory/engagement forms were identified that are well supported by the analyzed digital geogames. These engagement forms include exploring landscapes, learning about places, learning about specific topics, reconstructing the past, envisioning the future, connecting with action projects, and communicating.

There is so much that needs to be explored further, seeming like almost unlimited opportunities for further research. Further research may focus on how many children and at which ages would love to get engaged, how well such digital game-based applications would work in practice in attracting youth to participate, or how well they would compete with other commercial games that can be played just for fun. Possible negative side effects such as addiction to gaming may be discussed in further studies dedicated specifically to digital geogames.

Using geogames can also be an incentive with which youth can be initially engaged and then continue being engaged in other follow-up projects and incentives. Serious digital geogames also offer a whole range of learning opportunities. Further research can investigate the potential for

playful learning and the opportunities it represents for further geogames applications and tools. Human-computer interactions and the design of user interfaces that are playful, easy to use, and attractive is another inspiring area of research. Digital environments are constantly evolving and changing, bringing novel technologies into play to create mixed-reality, augmented and virtual reality environments that may inspire further developments in the area of game-based youth engagement in urban planning processes and the co-creation of living environments. Further investigations in the potential of empowering youth with digital game-based applications are needed as well as studies in how much they can enable youth to represent their interests, share their needs in becoming co-creators, designers, decision-makers and empowered members of the new, modern society of the future.

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Ethical Approval

All testing was done based on the country-specific ethic protocols.

GeoMinas Craft Game testing was approved by the Federal University Minas Gerais' valid protocols in 2016.

Geodesign Card Game testing was approved by the Federal University Minas Gerais' valid protocols in 2019.

FoodFinder testing protocol was approved by the Institutional Review Board (IRB) at Iowa State University IRB ID 15 – 629, approved on 10/05/2018, title: Big Data for Sustainable City Decision Making. All subjects provided informed consent by signing the informed consent forms.

Fingalcraft testing with youth was approved by the University College Dublin Human Research Ethics Committee for the study titled *Geodesign games for young people*, and the activity *Minecraft Online Workshop*.

Tirolcraft testing was approved by the Federal University Minas Gerais' valid protocols in 2016. The new resolutions for social sciences and humanities started to be developed in 2016: https://www.ufmg.br/bioetica/coep/resolucoes/. The first resolution of such for this research area "RESOLUÇÃO No 11/2017, DE 05 DE DEZEMBRO DE 2017" https://drive.google.com/file/d/1XoM80z79QUR7WdBwuFNoNrgLrb-YqkLf/view entered in vigor in 5 December 2017. All *Tirolcraft* experiments were executed before this date. They were approved by the public school of Tirol who took the geodesign games onboard as part of their pedagogical project in history and geography. The activities were held during school time, respecting school breaks. Teachers and some parents were present.

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ORCID iDs

Alenka Poplin https://orcid.org/0000-0002-2751-9326
Bruno de Andrade https://orcid.org/0000-0002-1191-8082

Supplemental Material

Supplemental material for this article is available online.

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Alenka Poplin is an Associate Professor at Iowa State University. She holds a PhD in Geo-information Science from Vienna University of Technology, a Master of Business Administration from Clemson University, SC and a Master in Surveying and Spatial Planning from the University of Ljubljana.

Bruno de Andrade is an Assistant Professor in Heritage, Values, and Project Decisions for Sustainability at the UNESCO Heritage and Values chair, Heritage and Architecture section, the Faculty of Architecture and the Built Environment, Delft University of Technology. He has a Bachelor and Master in Architecture and Urbanism from the Federal University of Espírito Santo, Brazil, and PhD in Architecture and Urbanism from the Federal University of Minas Gerais, Brazil.

Ítalo de Sena is a post-doc researcher at the Department of Geography at Masaryk University in Czech Republic. He holds a PhD in Geography from the Federal University of Espírito Santo, Brazil.