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Promoting sustainable development of contemporary housing estates. Gamification as an incentive methodology to support urban design

Abstract
The article explores the possibilities of improving urban planning in a direction towards sustainable development and the mitigation of contemporary climate change, as well as exploring the spatial aspects of the demographic processes in built development, concentrating on residential environments. By focusing on housing estates, the authors aim to address real-world challenges in urban planning and to emphasise the applicability of theoretical concepts to practical scenarios. The discussion underscores the significance of bridging the gap between theory and practice in urban planning education for students, architects, urban planners, and developers, as well as cities' inhabitants. The authors contend that unconventional methods, such as games, can serve as valuable resources for imparting the complex concepts related to urban planning. Several internationally recognised games are scrutinised and compared for their educational qualities in the context of sustainable development.

Keywords
Sustainable development of cities • urban design of residential areas • urban design education

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Introduction

This research aimed to explore the possible impacts on knowledge transfer using gamification, thus illustrating the links between theory and practical application in architecture and urban planning by evaluating the potential of selected urban games, including the 'Housing Estate Game', which was developed by the authors. A distinctive aspect of the aforementioned game is the use of augmented reality, which addresses the limitations of traditional teaching methods in promoting sustainable practices in architecture and urbanism, including increasing public participation in urban design processes.

The remainder of the article's structure is divided into sections devoted, in turn, to a literature review and an analysis of methods and materials; a presentation of the research on the 'Housing Estate Game', along with a comparison to other games; and, to conclude, a summary and discussion of the potential for using games in education.

Literature review

Research in the field of possible tools to improve sustainable development in cities frequently lacks insights from planning professionals regarding their perceptions of the necessity for environmental planning programs, as underscored in previously published literature (Jung, Park & Ahn 2019). This highlights the importance of consulting with planning professionals to further substantiate the need for environmental planning programs (Jung, Park & Ahn 2019).

Both the design of planning games which have sustainable development elements, and the reverse approach of designing certain processes, for example, participation and planning in the form of games, have noticeable benefits (Hassan & Hamari 2020). The concept of using games as a tool for research in design theory and method has a long tradition, as

> [g]ames offer a means of isolating certain aspects, or concepts, of designing for purposes of scrutiny. A game provides an environment for a group of players, acting with individual goals and a shared program, to make and transform complex configurations, free of functional requirements. (Habraken & Gross 1988)

While computer games can be used both in teaching a wide range of academic subjects and in psychological research (Fernandez & Ceacero-Moreno 2021, Khan & Zhao 2021, Arnold, Söbke & Reichelt 2019), according to Haahtela (2015), the usefulness of a game such as 'Cities: Skylines' as a stand-alone educational tool is limited due to the oversimplification of mechanics and the need to use potentially time- and resource-consuming modifications.

After examining selected computer games, Liarakou et al. (2011), in their article, also showed that there are 'games which explicitly address the three main dimensions of sustainability, i.e., environmental protection, social welfare, and equity and economic development'. Examples include 'Stop Disasters', 'Climate Challenge', '3rd World Farmer', and 'Ayiti: The Cost of Life'. Some of the games most geared towards learning to solve problems and creating equal-weighted communities, are 'Green Planet' and 'Age of Ecology' (Liarakou et al. 2011). Dieleman and Huisingh (2006), in their article 'Games by Which to Learn and Teach About Sustainable Development', using Kolb's experiential learning theory and the workshops they conducted, explored

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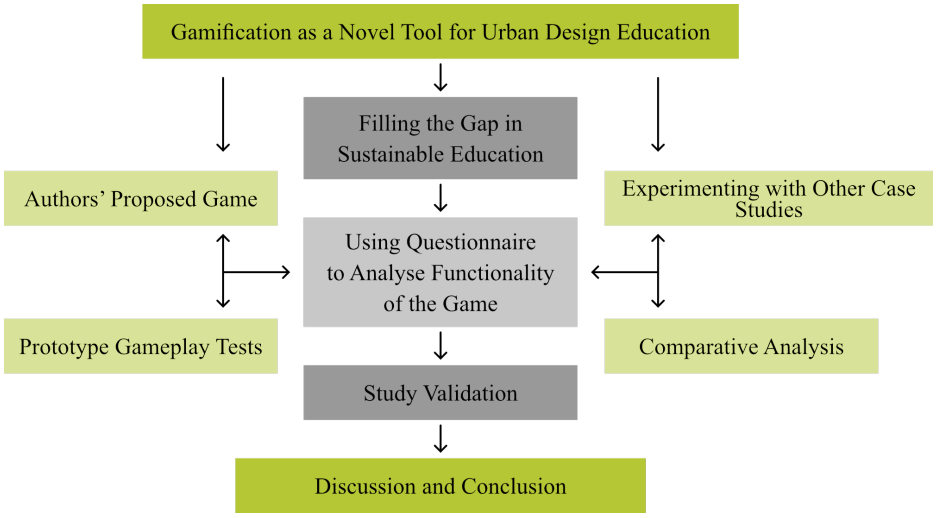

Figure 1. A diagram of the interrelationships between the issues addressed in the article and the research methods
Source: authors

the role of games in learning for sustainable development. The authors proposed and presented games in the field of sustainable development, such as the 'Harvest Game', which show what a lack of cooperation and care concerning common goods can lead to, and what needs to be improved in society to achieve a more sustainable life.

Materials and Methods

The following research methods were used in this paper: literature research, market research showing the spectrum of the application of games in the field of urban design and planning, and user surveys. The literature research was oriented towards the broadly understood use of games in improving the fields of design, architectural design, urban design, and spatial planning. A comparative assessment of the selected games was carried out, and the aspects of these games have been presented in this paper, including the authors' own game, the 'Housing Estate Game'. The selection of the titles was made from both digital and board games which had themes related to urban design and sustainable development. The focus was on the most widely available commercial and educational titles which had been described in the literature as examples of games used in education. Of the digital games, 17 were analysed out of approximately 30 available titles, while from the group of board games, 10 were selected out of an estimated 50–100 such titles. A diagram of the connections between the issues addressed in the article and the method is shown in Figure 1.

The methodology used in this study is based on the utilisation of card/board games as tools for use in education and public participation, particularly in the context of promoting sustainability. The authors refer to, and draw from, an urban card game they developed and implemented over 2022, 2023, and 2024 as part of the Urban Model research group at the Faculty of Architecture at the Silesian University of Technology.

Results

In 2022, work began on a project for the card game 'Urban Planning Game: Housing Estate Game'. The goal of the game's creators was to develop a teaching tool which would draw attention to the issues of housing densification. The 'Housing Estate Game' has been designed with different age groups in mind and takes into account that players may or may not have professional experience, and to this end, gameplay models of varying degrees of complexity were developed. The game itself consists of two decks of cards depicting models of urban quarters which are presented in 2D or 3D; these can be used for classic card games, and specialised games of varying difficulty. While the 2D deck allows for gameplay which is analogous to board games—albeit without a game board—the 3D deck allows players to get a better idea of the urban structure they are designing. Specialised gameplay models are based on scoring which depends on the individual urban indicators obtained. The 'Housing Estate Game's' deck of cards was developed on the traditional model with its division of four suits and thirteen ranks; in addition, however, the cards include references to the 3D models of each type of development created by the authors. These are available for download and through the Augment app (Fig. 2).

A single card depicts a plot of 120 x 80 m (an area of about 1 hectare), which is considered to be a representation of the size of a city block (Fig. 3). As one of the basic ideas was to simplify and virtualise development structures, some simplifications had to be made, though, this virtualisation does not compromise the connection between theory and practice.

For each development model, six urban indicators and parameters were distinguished and then summarised in tables. These tables can be found in the body of the source (eds. Bradecki, Dymarska & Sanigórska 2024), while graphs summarising the source data have been produced for the purpose of this article (Fig. 4 A–F). The highlighted indicators are for floor aspect ratio (FAR), share of built-up area, average number of storeys, number of dwellings per hectare, share of biologically active areas, and number of trees.

The game may be played in several modes. For beginners, the suggestion is to play the 3D deck in 'War' mode, in which the leading player chooses the urban indicator instead of the figure value. In this way, players pay attention to the indicator values' assignment to a colour (e.g., for the ecologist's colour, the indicators for biologically active areas and number of trees are significantly higher). For team games, solitaire stacks according to the value of the chosen indicator work well. For intermediate players, it is suggested that settlement plans be created from a deck of 2D cards and that the value of the indicators be calculated for the whole team. For the most advanced players, the game also

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Figure 2. (A) Diagram showing the density of the increases in development and the change in the indicators' values: number of trees, size of dwelling, type of communication, and population density. (B, C) Ace of Hearts card: from the 2D deck (B) and 3D deck (C) Source: Bradecki et al. 2024

Figure 3. Elements and content of the cards with explanations
Source: Bradecki et al. 2024

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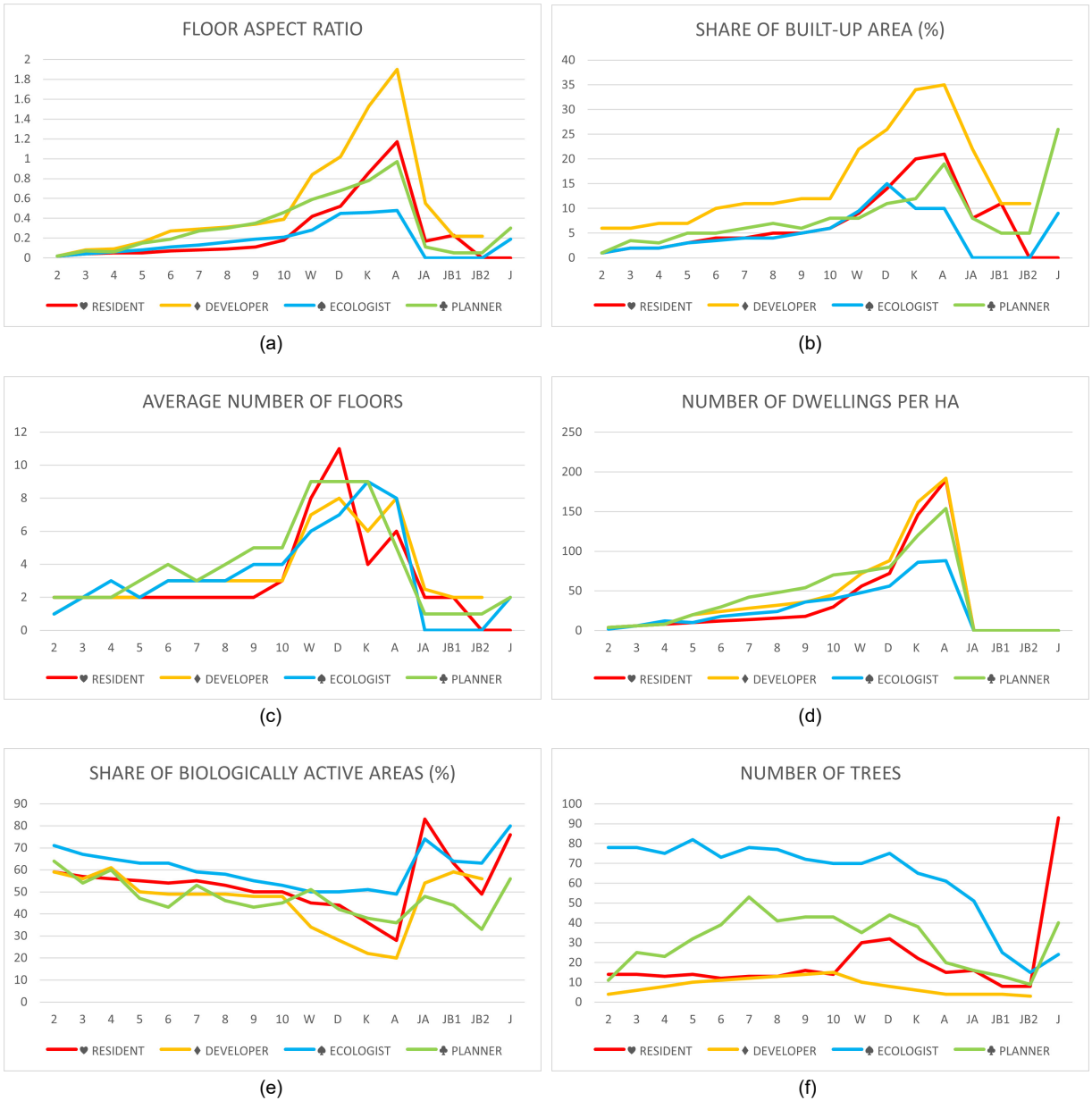

Figure 4. (A) FAR index graph, (B) Building area percentage ratio graph, (C) Average number of storeys graph, (D) Number of dwellings graph, (E) Biologically active area percentage ratio graph, (F) Number of trees graph
Source: own study, Bradecki et al. 2024

offers a board depicting plots of land, which players are to develop according to their intended use for a certain amount of funds. The board game allows the conscious planning of settlement spaces to be simulated. The authors considered that these indicators best illustrate the relationship between development density and green space. To compare the values of individual indicators and urban parameters, charts were drawn up for each card (Fig. 6). The graphs and the way in which the data were cross-referenced were validated in previously conducted studies (Bradecki 2021) based on selected case studies.

Drawing conclusions from the produced charts, it can be stated that with a rise in development density, there is a simultaneous increase in the number of storeys and in the built-up area ratio, accompanied by a decrease in the proportion of biologically active areas and the number of trees. The values of the indicators and parameters remain distinctive for each colour and figure on the charts.

Kuwaitscapes is another card game, though it is focused on the study of public spaces, with particular emphasis on their users and their needs (LSE 2023). The Game of Rent (The Game of Rent 2023), on the other hand, is a board game which addresses the affordable-housing crisis, and is based on scenarios dedicated to existing cities such as Nashville, Atlanta, or Boston. Cards Against Urbanity can be summed up in the words of one of its co-founders: 'There's a hunger for translating some of the topics and getting them more to the public in a way that's fun and engaging' (Bierend 2014). Through humour, the game teaches players about urban planning, which consequently makes it easier for players to

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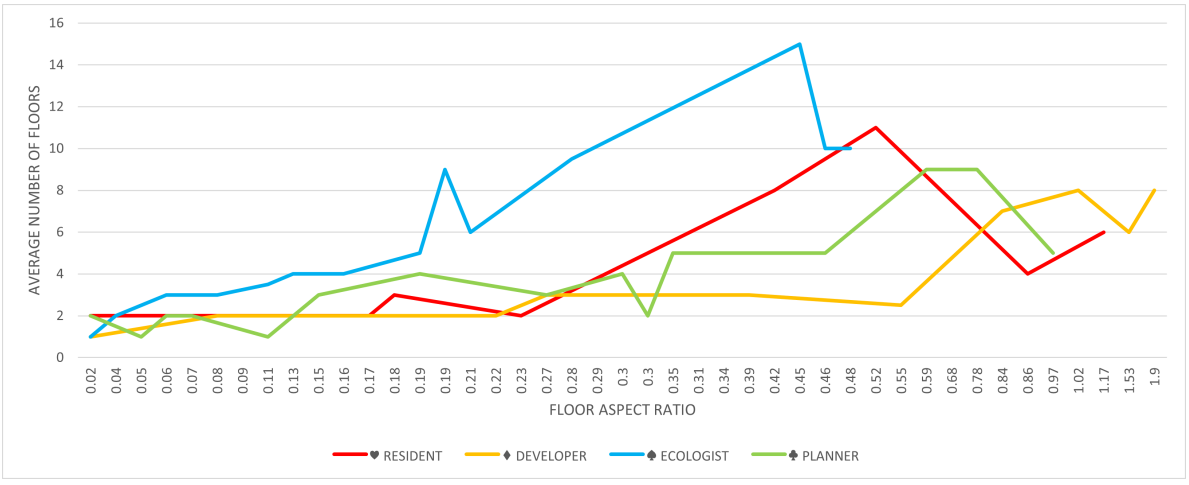
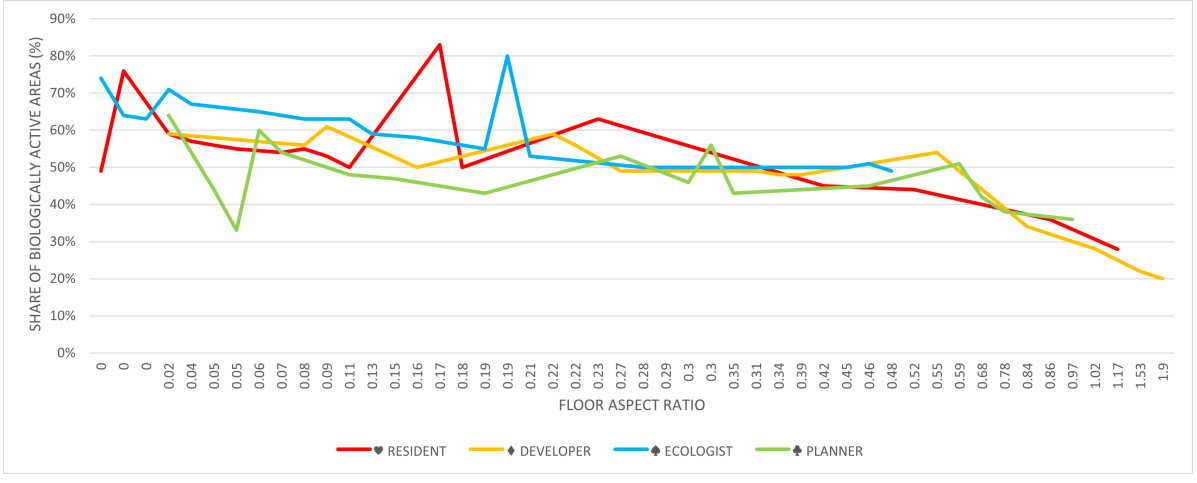


(a)



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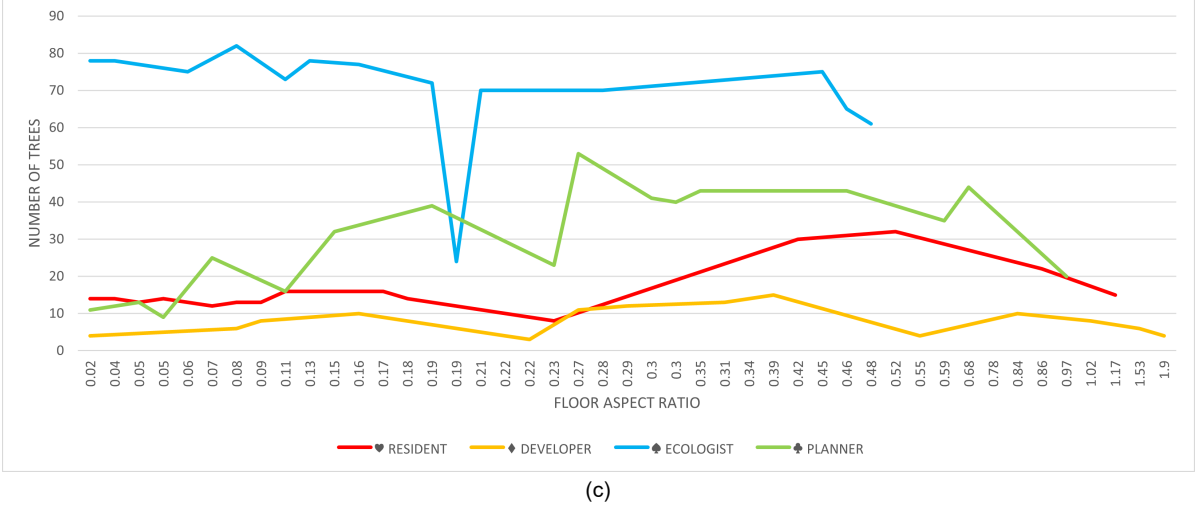

(c)

Figure 5. (A) Graph showing relationship of FAR to floor aspect ratio, (B) Graph showing relationship of FAR to percentage of biologically active area, (C) Graph showing relationship of FAR to number of trees
Source: own study, Bradecki et al. 2024

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take part in participatory processes. In terms of computer games, the genre known as 'city building simulators' emerged with the release of the 'Sim-City' game in 1989. The scale of the game and the possibility of observing a city's development over a wide time horizon made the experience of turning something complex and difficult into something organic and toy-like, possible (Bierend 2014). Now, 'Sim-City' has given way to the game 'Cities: Skylines', which allows gameplay at different scales and complexities (Hedrih 2023), and also supports fan-created modifications, which contribute to the game's greater usefulness as an educational and simulation tool (Haahtela 2015).

Discussion

Architecture and urban planning are specialised fields of study which, due to their form and ubiquity in everyone's life, can be effectively communicated to laypeople through a variety of media, both traditional and non-traditional. Analysing how games are used in planning processes reveals two main functions: the participatory function, where games are used to experiment and prototype solutions; and the educational function. The educational function may take the form of technical, urban, or architectural education, as well as social education, which is particularly important in the context of making participants aware of the often-contradictory expectations of individual groups of stakeholders who influence created spatial policy.

All the tools presented so far refer to virtual, theoretical cases and thus challenge players in this way. This is due to the need to simplify the mechanics as well as the necessity of reaching the largest possible group of users. Although examples of solutions created for specific, single processes are present, the peculiarities of such games, the restriction of gameplay to one specific area (DesignCurial 2017), the presence of complex rules (Play the city 2016) that often require constant supervision by a professional, and the significant cost of implementation (Widelec 2015), limit the possibility of integrating the games into other processes, and often prevent their commercialisation. The game created by the authors, on the other hand, makes it possible not only to quickly study the absorptive capacity of a site, but also to develop dedicated design solutions at the urban and architectural scale, which demonstrates the uniqueness of its assumptions. Innovative aspects of the described study consist of the inclusion of the urban indicators' importance in the game, which goes beyond traditional theoretical gameplay mechanisms. Similarly, the scenarios proposed in the game can serve as practical examples, reflecting the real complexity of the relationships present in urban design. Moreover, the interactive and engaging nature of the 'Housing Estate Game's' gameplay not only underscores its potential to create unique learning experiences, but also, as demonstrated in the discussion, emphasises the game's adaptability, which establishes its potential application across diverse educational contexts. The gameplay was carried out about 20 times, in different places: during classes with architecture students, during classes in high schools, and during dedicated events carried out with different players (young people, residents, councillors, etc.). After each game, participants filled out a short questionnaire with their evaluation of the game. In sum, this research makes a significant contribution to urban design and planning education methods by synthesising the aforementioned themes, and underscoring the practical and educational relevance of using the 'Housing Estate Game' as an illustrative and effective model for gamification in architectural and urban design education.

Conclusion

The 'Housing Estate Game' exemplifies the possibility of a game involving the creation of virtual estates, which has educational value by highlighting pro-ecological solutions as being natural and superior. The game clearly indicates that developing high-density environments while simultaneously incorporating a significant number of trees and biologically active surfaces is challenging, requiring necessary compromises.

Test games conducted as part of classes, along with the subsequent survey results, confirm that the original game discussed in the article was positively received as a method of learning about urban indicators. The game is designed for students of architecture, urban planning, and related fields, and addresses the nuances of spatial planning. However, the digital dimension itself (3D models) was not extensively utilised in the games, indicating another novel aspect of the present study.

Some limitations of the research include the authors' acknowledgment that the game focuses solely on specific spatial aspects of housing design. The simplifications within the game do not cover social, economic, or other factors, including the development of appealing public spaces as symbolised by finished cards of the highest value. Despite these limitations, the research successfully achieves its educational objectives. It is also impossible to create attractive homogeneous settlements with only low-value cards, reflecting suburbanisation processes occurring globally, processes which are unequivocally unfavourable in the context of the sustainable development paradigm. Therefore, the authors believe that the game fulfils the educational needs for SDGs (sustainable development goals), promoting sustainable land-use planning and management. The presented research highlights the necessity of continuing its application.

The virtualisation and parameterisation of design cases are solutions which help create games for architectural, urban, and planning education. Despite differences between cases designed with practical applications in mind and those for purely theoretical cases, multiple similarities should be noted, including the existence of principles and mutual dependencies. The study highlights the role of games in improving urban planning education, particularly in addressing sustainable development and climate change challenges within residential environments. It emphasises the need to bridge theory and practice, demonstrating how gamification can engage students, architects, urban planners, and city inhabitants in complex spatial planning issues. While many existing games, such as 'Kuwaitscapes', 'The Game of Rent', and 'Cards Against Urbanity', focus on specific urban topics, they often simplify mechanics to reach a broad audience. In contrast, the 'Housing Estate Game' stands out by integrating urban indicators and allowing players to develop dedicated design solutions at both the urban and architectural scales. The study underscores the game's adaptability to various educational contexts, making it a valuable tool for learning and simulation. This research contributes to the field by showcasing the 'Housing Estate Game' as an innovative model for gamification in architectural and urban design education.

Analysed games which were similar to the 'Housing Estate Game', demonstrate the value of further development and testing under various conditions, including different educational settings, age groups, and numbers of players. The authors intend to create a board game which utilises the existing cards, and will conduct a series of test games with students and young people. This endeavour will serve as the subject for subsequent research.

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