Digital Games for Technology and Sustainability in the Human-centred Built Environment: a literature review

Ming Shan Ng[1], Jack Tam[1], Clara Cheung[2], Tsukasa Ishizawa[3], Yifan Xu[2] and Akilu Yunusa-Kaltungo[4]

[1]Center for the Possible Futures, Kyoto Institute of Technology, Japan
[2]Department of Civil Engineering and Management, The University of Manchester, United Kingdom
[3]Institute of Industrial Science, The University of Tokyo, Japan
[4]Department of Mechanical and Aerospace Engineering, The University of Manchester, United Kingdom

ng@kit.ac.jp, tam@kit.ac.jp, clara.cheung@manchester.ac.uk, ishizawa@iis.u-tokyo.ac.jp, yifan.xu@manchester.ac.uk, akilu.kaltungo@manchester.ac.uk

Abstract -

The AECO sector increasingly calls for digital transformation to support sustainable development and a more human-centred built environment. In this context, the Society 5.0 dimensions, which emphasise *human-centred values*, *cyber-physical intelligence*, *socio-technical embeddedness*, *societal challenge orientation* and *system-level impact potential*, provide a lens for examining how digital technologies are conceived and deployed in the sector. Despite rapid technological advancement, challenges remain in operationalising these principles within complex socio-technical systems. Gamification has been explored as a potential response, yet its contribution to Society 5.0-oriented transformation remains fragmented. This study conducts a systematic literature review of 98 publications from the past five years (2021-2025), each presenting a game or gamified application in the sector. The review analyses their correspondence to the Society 5.0 dimensions. The results indicate that many existing games are not primarily designed for engagement or enjoyment. Research-oriented games are predominantly targeted at students rather than industry practitioners or the general public. Most applications operate at the building scale and focus on the operation phase of the lifecycle. Furthermore, a heatmap analysis reveals systematic patterns: Amongst the minority that are engagement-oriented games, these tend to strengthen *human-centred values* and *socio-technical embeddedness*; decision-making games are more closely associated with *system-level impact*. Notably, no reviewed games address the end-of-life stage of buildings, while scenario-based interactive games often align with individual-level human values. The study concludes by identifying key gaps and outlining future gamification requirements to better align digital innovation in the AECO sector with the human-centred and system-oriented aspirations of Society 5.0.

Keywords -

Digital Games; Gamification; Society 5.0; Technology; Sustainability; Literature Review

1 Introduction

1.1 Society 5.0

Industry 5.0 has been emerging globally to rethink the role of humans and place humans at the centre of industrial development through sustainability, resilience and human-centredness. This aligns with a new overarching vision for society - Society 5.0 - that envisions a human-centred physical and cyber space with advanced technologies including artificial intelligence (AI), information and communication technologies (ICT) that enable sustainable development in environment, economy and society. Ageing societies, inclusiveness and equality are considered through technological development. In Europe, policy-makers and scholars are exploring a neighbouring concept to envision decentralised autonomous cities and human digital twins [1]. In Japan, the government has been pushing a human-centred system in Society 5.0 that includes the transdisciplinary concepts of digitalisation, integration and sustainability [2]

Nevertheless, there are clear challenges in Society 5.0 regarding humans, technologies and values in a sustainable society in the physical space. These multi-dimensional challenges include how to achieve *human-centred values*, such as health and wellbeing, safety and inclusiveness in society, as well as unknowns in *societal challenge orientations* to different extents. The interactions between humans, humans and technologies, physical and cyber space and amongst each other as complex systems within systems entail *socio-technical embeddedness* Also, the complexity within physical and cyber spaces with AI and intelligence-based technologies entails new forms of *cyber-physical intelligence*. In general, a system-level rethinking of the potential impacts in the physical world is necessary to adapt and optimise these challenges to foster sustainable development in Society 5.0 through digital transformation, which refers to an inter-connected set of discoveries and inventions [3].

1.2 Construction 5.0

The World Economic Forum reveals that the architecture, engineering, construction, and operations (AECO) sector is responsible for 13% of the global gross domestic product (GDP), employs more than 100 million people, and accounts for 79% of total greenhouse gas emissions and 88% of climate adaptation costs. However, the sector suffers from low digitalisation and innovation. It is one of the least digitised in the world and requires a systematic approach to digital transformation to foster a sustainable development. The industry embraces a new movement of Construction 5.0, in reference to Industry 5.0 and Society 5.0 in AECO, to drive digital transformation through digitalisation, integration and sustainability to different extents [4, 5].

In correspondence to the five dimensions of Society 5.0, the AECO sector has been trying to achieve *human-centred values* to improve human wellbeing such as worker health and safety, as well as continuous improvement in knowledge and skills [6, 7]. The industry has adopted automa-

tion and robotics in construction to address broader social challenges such as ageing society and labour shortages [8, 9]. In addition, recent research reveals the complex ontology networks and interactions between the different human roles, resources, conditions, artifacts, processes, attributes, values and risks in adopting automation technologies to achieve sustainability in AECO. This shows that *socio-technical embeddedness* is significant and requires more integrated management for Construction 5.0 [10]. Recent studies have also examined real-time digital twins for automation and robotics in construction management [11] *Cyber-physical intelligence* enables human-centred controls in, for example, human-robot collaborations [12].

1.3 Gamification

Given the complexity of the AECO sector, gamification has been one approach to encourage and assist the industry to comprehend and stimulate strategies through experiential learning to different extents. Suits [13] defines a game as 'the voluntary attempt to overcome unnecessary obstacles'. He suggested that a game possesses three components of prelusory goal, constitutive rules and lusory attitude. The term gamification was coined by Pelling in 2002 and hit the mainstream around 2010 [14]. The elements of a gamified system can be categorised into three groups [15]: (1) *dynamics* defines the big-picture aspect of the game and includes elements such as constraints, narratives, progression and relationships; (2) *mechanics* defines the processes that drive actions forward and includes elements such as challenges, chance, competition, cooperation, feedback, resource acquisition, rewards, transactions, turns and win states; and (3) *components* specify the corresponding instantiations of *dynamics* and *mechanics* such as quests and points [16]. Garneau [17] identifies fourteen forms of fun in games, ranging from beauty and immersion to competition, discovery and social interaction, while Heeter et al. [18] shows these more prevalent in commercial than educational games.

1.4 Gamification in AECO Research

Recently, researchers have been exploring gamification approaches for research and education on technology and sustainability to different extents. Yanai and Ishikawa [19] developed an immersive environment in VR to investigate the learning experience at Osaka Castle. Ng and Chen [7] developed a teaching game using the online platform *Slido* to investigate students and practitioners' perceptions of lean terminology. Tan et al. [12] reviewed the literature on augmented reality (AR) for human-robot interactions to investigate innovations in pedagogy. Ng and Hall [20] developed an online game to allow players to experience a round of traditional design-bid-build design process and a second round of lean-based Target Value Design for digital fabrication. Kastner et al. [21] designed an online game in 3D BIM to let players learn about lifecycle thinking for renovating a historic building in Switzerland. Harichandran et al. [22] presents a virtual reality (VR) game with digital twins to train workers about construction safety.

Some scholars had reviewed existing academic games or gamification in AECO. For example, Ilbeigi et al. [16] conducted a scoping review on Scopus of 103 game-based educational solutions for construction engineering in the past two decades. They differentiated the basic information of the article, such as titles, and analysed several factors, such as whether each study developed a novel gamified solution based on a learning theory and specific its specific area of domain. Bhatnagar et al. [23] reviewed 96 lean simulation games from a selection of 52 articles. Articles were analysed for basic information, such as authorship, using social-networks analysis. They found that the International Group for Lean Construction (IGLC) developed a large number of lean games in AECO. They show that a few authors collaborate extensively, while others in the periphery are beginning to publish and collaborate. Oke et al. [24] identified five challenges to the adoption of gamification for sustainable construction, including hesitation in adopting and lack of budgeting for innovation, with a questionnaire survey.

Nevertheless, no recent articles have reviewed academic games, in particular, about technology and sustainability in AECO.

1.5 Research Objectives

To help researchers and industry think about technology and sustainability in Society 5.0 and Construction 5.0, this work presents a systematic review of the literature of publications from the past five years to investigate the recent trends of digital games in AECO and their relevance to the promotion of technology and sustainability. This research possesses two overarching research questions of **(RQ1)** what are the recent trends in game development in AECO? and **(RQ2)** what can be the foci when researchers develop games for AECO in Society 5.0? In this regard, this work correlates gamification to the five dimensions in Society 5.0 of *human-centred value*, *socio-technical embeddedness*, *cyber-physical intelligence*, *societal challenge orientation* and *system-level impact potential*. The research objectives of this work include **(OB1)** identifying recent trends and features of recent game development in AECO through a systematic review of the literature; **(OB2)** to analyse the correlations between the indicated features and the five dimensions in Society 5.0; **(OB3)** to elaborate on potential topics in game development to foster Society 5.0 in AECO. This article summarises the preliminary of this systematic literature review and a further in-depth analysis will be presented in future publications.

The structure of this article is organised as follows: Section 2 describes the systematic literature review methodology; Section 3 presents the results of recent trends and features; Section 4 discusses the co-occurrence pattern analysis with Society 5.0 dimensions; and Section 5 concludes with limitations and future research directions.

2 Research Methodology

To conduct a systematic literature review, the first author of this work ran a first-round Scopus search with the keywords of keyword group 1, which comprises "gamification" or "digital games", and keyword group 2, which comprises "construction" or "building" or "architecture". The search includes journal articles and conference proceedings published in the past five years (2021-2025) in the fields of AECO only. This resulted in 1279 articles. The first author then screened the abstract of every article to eliminate those that do not include an original development of gamified solutions, those about research of game theory or game modelling, those that gamify a survey or other types of research but not a game development, those

Table 1. The basic information of the selected 98 articles in this work. "J" refers to a journal article; "C" refers to a conference proceeding.

Authors	J/C	Ref	Authors	J/C	Ref
2025 (25 literature)					
Boyacioglu et al.	J	[25]	Cao et al.	J	[26]
Emiroglu et al.	J	[27]	Hao et al.	C	[28]
Hardy et al.	C	[29]	Hu et al.	J	[30]
Hung et al.	J	[31]	Jacob et al.	C	[32]
Jang et al.	J	[33]	Jiang et al.	J	[34]
Kastner et al.	C	[21]	Kilis et al.	J	[35]
Ng & Chen	C	[7]	Ng et al.	C	[36]
Pappas et al.	C	[37]	de Sena et al.	J	[38]
Taha et al.	J	[39]	Turk & Bozkurt	J	[40]
Voinea	C	[41]	Wang et al.	J	[42]
Wang et al.	J	[43]	Yang et al.	J	[44]
Yanai et al.	C	[19]	Zhang et al.	J	[45]
Zielke et al.	C	[46]			
2024 (19 literature)					
Arbesser-Rastburg et al.	C	[47]	Arslan et al.	J	[48]
Caliskan et al.	C	[49]	Carrasco-Beltran et al.	J	[50]
Chen et al.	J	[51]	Elenany et al.	J	[52]
Fawad et al.	C	[53]	Fawad et al.	J	[54]
Ilbeigi et al.	J	[55]	Joy et al.	J	[56]
Kolokotsa et al.	J	[57]	Park et al.	J	[58]
Pickersgill et al.	C	[59]	Sa Alves et al.	J	[60]
Speiser et al.	C	[61]	Stevens et al.	C	[62]
Tay et al.	J	[63]	Vandenabeele et al.	J	[64]
Xiao et al.	J	[65]			
2023 (20 literature)					
Alexander et al.	C	[66]	Alp et al.	J	[67]
Angheluta et al.	J	[68]	Arefazar et al.	C	[69]
Bhat et al.	C	[70]	Borucka et al.	J	[71]
Cook et al.	J	[72]	Diaz-Aleman et al.	J	[73]
Ehab et al.	J	[74]	Ernstsen et al.	J	[75]
Jungmann et al.	C	[76]	Kalak et al.	C	[77]
Li et al.	J	[78]	Martinez et al.	J	[79]
Ospina-Bohorquez et al.	J	[80]	Sorensen et al.	J	[81]
Tabi et al.	J	[82]	Villamil et al.	J	[83]
Wang et al.	C	[84]	Speiser et al.	C	[85]
2022 (13 literature)					
Alves et al.	C	[86]	Anschutz et al.	C	[87]
Argiolas et al.	J	[88]	Avendano-Uribe et al.	J	[89]
Comai et al.	C	[90]	Getuli et al.	J	[91]
Goli et al.	J	[92]	Jiang et al.	J	[93]
Kassi et al.	C	[94]	Lee et al.	J	[95]
Potseluyko et al.	J	[96]	Shareef et al.	J	[97]
Vollmer et al.	J	[98]			
2021 (21 literature)					
Biotto et al.	C	[99]	Chen et al.	J	[100]
Ezzeddine et al.	J	[101]	Filippova et al.	C	[102]
Gangolells et al.	J	[103]	Goubran et al.	J	[104]
Gutierrez-Rodríguez et al.	C	[105]	Harichandran et al.	C	[22]
Heins et al.	C	[106]	Huang et al.	C	[107]
Jacobsen et al.	C	[108]	Kan et al.	C	[109]
Koutsabasis et al.	C	[110]	Martín-Hernández et al.	J	[111]
Meuser et al.	C	[112]	Ng & Hall.	C	[20]
Putz et al.	C	[113]	Riedlinger et al.	C	[114]
Schnieder et al.	C	[115]	Walls	J	[116]
Yan et al.	C	[117]			

that do not involve any digital tools, as well as those that review existing commercial games or those review literature about games. In case of those presenting the same game in multiple articles, only the most relevant article was selected. This resulted in 98 relevant articles as shown in Table 1.

To answer RQ1 and achieve the objective OB1, all authors reviewed each article in detail to identify the features of each of the 98 games from the selected literature. The features are identified under six categories of *target player*, *scale*, a *building lifecycle stage*, the *research goal*, any focused *digital features* significantly involved, as well as any *Society 5.0 concepts* involved [2, 4]. Moreover, this work includes an evaluation of the five dimensions presented in Section 1. The results of this analysis are explained in Section 3. Furthermore, this work analyses the correlations amongst the features through heatmap visualisation. The results answer RQ2 and achieve the objectives OB2 and OB3 are discussed in Section 4.

Each article was independently coded by at least two authors across six feature categories (target player, scale, lifecycle stage, research goal, digital features, Society 5.0 concepts) using binary present/absent labels. Multi-label coding was permitted, and disagreements were resolved through discussion or third-author adjudication. The heatmap in Figure 3 shows conditional co-occurrence percentages: each cell = (articles tagged with both the row and column features) /(articles with the row feature) × 100, rounded to the nearest integer. For example, 16 of the 23 'Cultural Preservation' games involve the 'Building' scale, yielding approximately 70%. These values represent co-occurrence patterns, not statistical correlations; normalisation is row-based, and multi-label articles contribute to all applicable categories.

3 Recent Trends and Features

This section presents the results of the identified features in the seven categories for the analysis.

Target Player: Based on systematic review of the literature, recent trends in digital games show that 45% are designed to target AECO students at universities, while 40% target professionals in the sector. For example, Arbesser-Rastburg et al. [47] developed an escape room game in VR to teach AECO students about building energy. In addition, 28% are targeted at visitors or end-users of the facilities involved in those games. For example, Yanai and Ishikawa [19]'s VR experiment aims to improve visitors' experience when visiting Osaka Castle in Japan. 6% target on general households. For example, Hao et al. [28] uses a game approach to help the decision-making of general households and governors, respectively, about the management of solid waste. 5% target kids and/or teenagers. For example, Emiroglu et al. [27] used minecraft to teach primary and secondary K-12 students about flood mitigation. 4% target on governors or policymakers; while only 1% target on elderly. For example, Hung et al. [31] gamified a cycling exercise for residents in long-term care homes.

Scale: The recent trends show eleven scales in game development. 41% of the games developed in the past five years are games with buildings. For example, Kastner et al. [21] developed an online 3D building game of the existing Hotel Schatzalp in Davos, Switzerland, for a case study of lifecycle thinking for architecture renovation. 28% present games with a project scenario. For example, Ng and Hall [20] developed a game to make a salad plate that mimics van Gogh's The Starry Night painting as a design project for students and professionals to learn about the lean-based Target Value Design approach for digital fabrication. 20% of the games developed comprise a campus, a site or a landscape in the gaming environment. For example, Turk and Bozkurt [40] presents an AI-based board game to teach AECO students about landscape architecture. 18% are about an individual person or a role. For example, Ng and Chen [7] developed a game for everyone to learn their own perception of lean terminology from Japan. 18% gamified user experience and 16% gamified urban and cityscape; while 14% games are about infrastructure assets such as bridges. 5% are community-based games. For example, Wang et al. [43] presents a community game in a smart green village in China. 2% of the gamifications are specifically about climate such as wind and furniture, respectively, such as the gamified bike in [31]. Only 1% gamified softscape such as audio.

Lifecycle Stage: This work also presents which of the commonly known six lifecycle stages are more frequently presented in a game. 38% and 27% of the games reviewed are developed for the operational stage and the construction stage, respectively. For example, Boyacioglu et al. [25] presents a game to address the delays of construction projects. 19% developed games for the design stage, while 12% developed games for the pre-design planning and initial design stage. 9% games are designed for urban

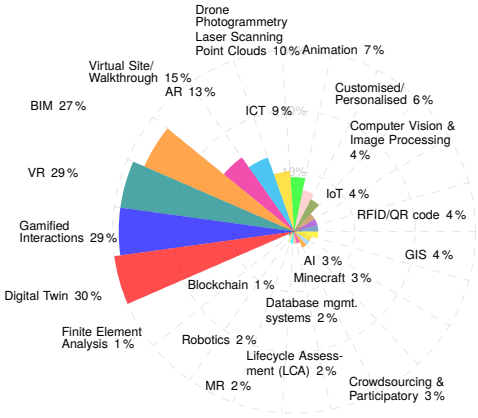

Figure 1. Recent 23 trends of digital features in digital games in AECO.

planning. Nevertheless, no game has been developed in the last five years for the end-of-life stage (afterlife) of a building or infrastructure.

Research Goal: To assist researchers and game developers understand how games could be developed in the future, this work also reveals that there are 18 research goals that have been addressed in the past five years. 62% of the games were developed for educational and communication purposes. Surprisingly, only 37% of the 'games' were gamified for people to play. Many of the developments in the reviewed literature do not aim for fun. In this regard, a further discussion is provided in Section 4. 26% and 20% of the games aim to assist decision-making and improve efficiency, respectively, such as reducing project delays in Boyacioglu et al. [25]. 19% aim for co-creation and collaboration amongst players. For example, de Sena et al. [38] developed a participatory planning system to collect spatial data from minecraft and improve collective governance in urban planning for co-creation. 18% of the games were developed to explore cyber-physical interaction and resource management, respectively. 17% were developed to provide information to players for knowledge sharing. 10% aim to improve site management and safety training, such as Harichandran et al. [22], respectively. 9% gamified, for example, on the urban scale, to mitigate safety and resilience. 7% aim for collective governance; while 7% promote modular construction and 6% explore new processes or innovation in the built environment. For example, Jang et al. [33] presents a gamification of crane lifting tasks in digital twins to improve a prefabricated bridge deck assembly process. The salad game in Ng and Hall [20] facilitates integrated design processes to stimulate systemic innovation. 5% aim to explore acceptability amongst players. For example, Hung et al. [31] and Ng and Chen [7] used gamification to explore people's perceptions. 5% were designed to perform seismic damage assessment, while 3% were aimed at boosting business-or-finance-related activities. Surprisingly, only 3% promote a clean and green built environment.

Digital Features: Furthermore, in response to emerging needs in digital transformation in AECO, this work reveals the trends of 23 digital and technological features in recent digital game development. Based on the literature review, 30% of the gamification research developed a digital twin such as Jang et al. [33]; while 29% comprise gamified interactions such as Hardy et al. [29]. 29% use VR, 13% use AR and 2% use Mixed Reality (MR) features, respectively. 27% include BIM such as Kastner et al. [21]. 15% include virtual site or virtual walkthrough such as Zhang et al. [45], Only 6% of the games include customised or personalised and only 2% are games about robotics. For example, Hu et al. [30] developed a customised experience in the archaeological site museum through gamification.

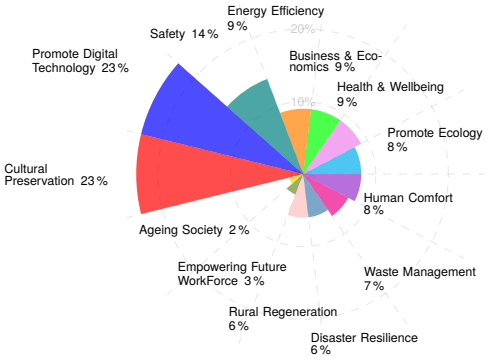

Figure 2. Recent trends in games relevant to the concepts in Society 5.0 .

Society 5.0 Concepts: To answer RQ2, this work identifies 13 Society 5.0 concepts that can be found in recent game developments based on the reviewed literature. Amongst all, 23% of the games have been developed for cultural preservation and promoting digital technologies, respectively. Games about safety in AECO are also relatively popular, such as Harichandran et al. [22]. Energy efficiency, health and wellbeing, and human comfort can also be found in around 8-9% of the publications reviewed. Games that simulate business related activities can be found in 9% of the games. For example Zielke et al. [46] developed a serious digital game about lean-based logistics to improve efficiency and therefore cost effectiveness. Very few games explore future workforce and ageing society respectively.

Five Dimensions in Society 5.0: To achieve OB2, this work further investigates a more detailed overview of the five dimensions in Society 5.0 as described in Section 1. The differentiation of the recent games are relatively well distributed across these dimensions. 33% of the games explore *human-centred values*; 28% explore *cyber-physical intelligence* through, for example, digital twins in the game development such as Voinea [41]. 27% delve into *socio-technical embeddedness*, while 23% look at *societal challenge orientation*, respectively. 20% explore *system-level impact potential*.

4 Discussions about Games for Society 5.0

The analysis of heatmap-based co-occurrence patterns in Figure 3 provides a systematic overview of how current

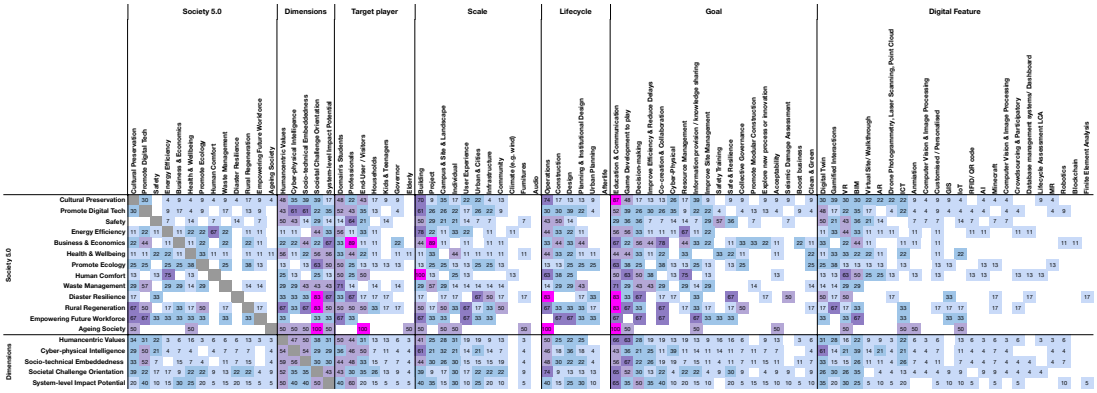

Figure 3. Heatmap of row-normalised conditional co-occurrence percentages across game features, Society 5.0 concepts and the five dimensions. Each cell shows the proportion of articles with the row feature that also exhibit the column feature, rounded to the nearest integer. The number in each cell refers to the percentage of the correlations. For example, amongst all 23 games about cultural preservation, 16 of them, i.e. rounded-up to 70%, involves gamification of buildings.

digital game-based developments in the AECO sector align with the broader aspirations of Society 5.0. While certain themes such as safety training, cultural preservation, and digital technology promotion are well represented, other critical dimensions remain underexplored. This reveals both the strengths and the limitations of current gamification practices in supporting a more human-centred and system-oriented built environment. This work achieves OB3 to discuss potential game developments to foster Society 5.0 in AECO.

4.1 Dominant Clusters and Underexplored Needs

Amongst the most prominent trends, safety-related games exhibit strong integration across multiple lifecycle stages, particularly construction and operations. These games frequently use digital features such as gamified interactions and immersive environments, with the primary goal of supporting safety training and hazard awareness. This is reflected in the heatmap, where the 'Safety' row shows relatively high co-occurrence values for the 'Construction' lifecycle stage (50%), as well as 'Gamified Interactions' (21%) and 'VR' (43%) amongst digital features. Cultural preservation is another area of significant focus, with many games using VR, digital twins and walkthroughs to enhance user experience in heritage contexts. Similarly, promoting digital technology is a recurring theme, often linked to BIM, gamified learning and educational communication. These clusters suggest a tendency to deploy games in domains where the benefits of technology can be clearly demonstrated, risks are manageable and regulatory constraints are lower.

Nevertheless, despite the emphasis on human-centredness in Society 5.0, certain societal needs are noticeably absent. The concept of ageing society, for instance, is scarcely addressed in the reviewed games. Very few applications are designed with elderly users, children or general households in mind. Most games target students and professionals, thereby limiting their societal reach. Similarly, lifecycle stages such as the end-of-life stage of buildings, covering topics such as *system-level impact* and *socio-technical embeddedness* in deconstruction, reuse and circular design, receive almost no attention, despite their importance for sustainability and long-term planning. These gaps point to a missed opportunity for games to contribute to inclusive design, intergenerational equity and circular economy transitions. Several factors may explain these gaps: recruiting vulnerable populations (elderly, children, non-expert households) poses ethical and methodological challenges unfamiliar to technically oriented AECO teams; the end-of-life stage lacks commercial incentive relative to design or operations; and disciplinary silos between AECO and social science or gerontology limit cross-pollination of methods. To address this, cross-disciplinary co-design workshops involving diverse end-users, partnerships with care facilities and community organisations, as well as policy-driven agendas linking circular economy mandates to gamification could broaden both target audiences and thematic scope.

4.2 Mechanics and Embeddedness

The analysis also highlights the importance of game goals and mechanics in shaping their alignment with Society 5.0 dimensions. While a majority of the games are developed for educational and communicative purposes, only a minority are designed to be engaging or enjoyable in a conventional sense. This suggests that many academic games prioritise knowledge transmission over player experience, which may hinder their impact. Interestingly, games developed for decision-making and co-creation tend to correlate more strongly with dimensions like *system-level impact*. These findings imply that the transformative potential of games lies not only in their content or digital features, but also in how they frame interaction, collaboration and agency. The heatmap supports this: 'System-level Impact Potential' co-occurs more strongly with 'Professionals' (60%) than 'Domain's Students' (40%) as target players, and shows relatively strong co-occurrence with the Society 5.0 concept of 'Business & Economics' (30%) compared to other concepts.

Socio-technical embeddedness, in particular, emerges as

a critical but underutilised dimension. It is most effectively realised in games that involve collective governance, participatory planning and stakeholder negotiation, especially at urban, community or site scales. However, many games still treat social contexts, institutional structures and power dynamics as external conditions rather than integral parts of gameplay. Even when advanced technologies such as VR or BIM are used, their contribution to embeddedness is limited unless supported by mechanics that model real-world complexity, such as role-based decision-making or scenario-based negotiation.

To support the broader transformation envisioned in Society 5.0 and Construction 5.0, future game development must go beyond technology demonstrations or visual simulations. There is a clear need for games that support participatory and experiential learning, that model trade-offs and systemic consequences, and that engage a broader spectrum of users beyond students and professionals. Addressing the end-of-life stage of buildings, designing for inclusivity and accessibility, and embedding socio-technical complexity into gameplay will be essential steps. Only by expanding the scope, depth, and diversity of game-based applications can the AECO sector fully leverage gamification as a tool for human-centred, sustainable, and system-level innovation.

4.3 Limitations and Future Research Directions

This review is restricted to Scopus-indexed peer-reviewed publications from 2021-2025. Industry-developed games, commercial applications and grey literature are excluded. The findings may under-represent applied solutions that influence practice but fall outside the academic literature. This study has several limitations that should be considered when interpreting the findings. First, the analysis is based on thematic co-occurrence and correlation patterns derived from a systematic review. While this approach enables a structured comparison across a large body of literature, it does not assess the depth, quality or effectiveness of individual game implementations. Moreover, recent AECO game developments rarely engage explicitly with the fourteen forms of fun. As such, the results indicate patterns of emphasis rather than evidence of impact or causal relationships between game design features and societal outcomes. Second, the classification of game features, Society 5.0 concepts, and the five dimensions necessarily involves a degree of interpretive judgment. Although a systematic and consistent coding framework was applied, some dimensions, particularly *socio-technical embeddedness* and *system-level impact potential*, are conceptually broad and may be operationalised differently across studies. The resulting heatmap therefore reflects relative emphases rather than definitive or exhaustive categorisations. Finally, each game was treated as a single unit of analysis, without accounting for differences in maturity, scale of deployment, duration of use or institutional embedding. Early-stage prototypes and long-running platforms are weighted equally, which may obscure important variations in adoption, learning outcomes or long-term influence.

Although this study provides a structured overview of how digital games relate to Society 5.0 concepts in the built environment, the analysis is primarily based on thematic correlations and does not evaluate the depth or effectiveness of individual implementations.

Future studies should move beyond the current concentration on technology demonstration, safety training and cultural preservation. They should explore how games can support more complex social challenges. In particular, there is a strong need to address under-represented themes such as ageing society and inclusive participation, by designing game-based applications for elderly users, households and non-expert stakeholders. Sustainability oriented games should also evolve from technically focused simulations toward participatory and experiential formats that allow players to engage with environmental trade-offs, long-term impacts, and collective responsibility. Moreover, the near absence of afterlife stage applications highlights an important opportunity for future research to develop games that address deconstruction, reuse, and circular economy strategies. Finally, expanding game-based approaches towards decision-making, governance and system-level exploration may enhance their potential to support the broader socio-technical transformation envisioned in Construction 5.0 and Society 5.0.

5 Conclusions

This paper presented a systematic review of 98 digital games in the AECO sector, analysing their alignment with the five dimensions of Society 5.0. The results reveal that while current games often focus on safety, cultural heritage and digital technology promotion using tools such as VR, BIM and digital twins, critical areas like ageing society, inclusive participation and the afterlife stage of buildings remain largely overlooked. Most games are developed for students and professionals, with limited engagement of diverse or vulnerable user groups. Moreover, while many games employ advanced digital features, few fully support *socio-technical embeddedness* or *system-level impact*, often lacking participatory or collaborative mechanics. To better support the goals of Society 5.0 and Construction 5.0, future gamification efforts should go beyond education and demonstration. There is a clear opportunity to design more inclusive, participatory, and systems-oriented games that engage broader audiences and address complex societal challenges in the built environment.

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