Integrated Project Delivery with Citizens (IPD+C): Co-Creating Projects Through Gaming as a Service

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Abstract
Co-creation represents the highest level of community engagement in urban projects and moves beyond traditional tokenistic methods focused on information sharing or option selection. It values local knowledge as much as technical expertise, requiring a two-way knowledge exchange between professionals and citizens. This concept is crucial for building an environment where citizens are not just passive recipients of information but active contributors to the project. While collaborative amongst project stakeholders, the current cutting-edge Integrated Project Delivery (IPD) method lacks the community engagement dimension, leading to public concerns and project derailments. This research addresses this by proposing a theoretical framework and the corresponding research path to incorporate citizens as co-creators in IPD projects via gaming. The framework uses a Knowledge Graph (KG) anchored by an Architectural Engineering and Construction (AEC) ontology and a gaming ontology. This KG forms the foundation of a custom-built gaming framework, facilitating creative interactions between project stakeholders and citizens.

Keywords: co-creation, gaming, IPD, knowledge graphs, community engagement, citizen science, AI/ML

1 Introduction

The construction industry often endures communication obstacles externally with the public and internally among stakeholders. These communication gaps impede project success, resulting in misunderstandings, delays, and worse outcomes. Integrated Project Delivery (IPD) represents a delivery approach that enhances collaboration by involving all parties—owners, architects, engineers, contractors, and subcontractors—early in project decision-making. IPD promotes shared risk and reward, ultimately enhancing efficiency and project outcomes.

However, IPD does not emphasize community involvement, which could trigger resistance and project setbacks. This shortcoming is especially relevant when public opposition towards urban projects, often protests, legal challenges, or negative public sentiment, has become prevalent due to a lack of transparency and communication (Jannack et al., 2015). For instance, Sidewalk Labs' unsuccessful venture to launch its smart city initiative in Toronto illustrates how disastrous public engagement can doom a project, as it failed to adequately address public concerns over data privacy, surveillance practices, and corporate overreach. (Goodman et al., 2020).

To address these obstacles, this study develops a theoretical framework for integrating gaming to enhance citizen engagement in IPD-engaged projects. This approach entails incorporating elements and principles of game design into urban project contexts to facilitate and motivate creative interactions. Gaming is not just a tool for entertainment but a powerful medium that can simplify and contextualize technical knowledge for non-professional citizens and empower them to contribute local knowledge and creativity. It offers a dynamic and interactive

environment of active learning, problem-solving, and collaboration. Most importantly, it has the potential to bridge communication barriers, ensuring that all stakeholders are on the same page and reassuring the audience about its effectiveness in promoting effective communication.

Gaming in IPD enables two-way knowledge exchange between professionals and citizens. Technical knowledge is simplified and contextualized for non-professional citizens, while citizens contribute local knowledge and creativity during gameplay. This approach values local wisdom as much as technical expertise, promoting co-creation, where better solutions are innovated in partnership with the community. At a deeper level, the urban project can be understood as a game with players from different factions collaborating towards some common objective while competing for their respective self-interests. Many project management problems could be evaluated with this perspective, as the rich insights from game research could inspire new approaches to some old issues in AEC.

The proposed framework is designed to put citizens at the forefront of IPD projects. It invites citizens as co-creators through a custom-built structured gaming environment for each project. This setup uses a Knowledge Graph (KG) that captures key concepts from technical documents and professional-citizen debates. The KG is anchored to an AEC (Architecture, Engineering, and Construction) ontology and a gaming ontology to establish a link between the domains. This connection allows for a merging of game elements with project-related information. The KG helps choose game elements from a collection of components assembled to form a customized game structure, empowering citizens to contribute meaningfully to the project and making them feel integral to the process.

This study aims to demonstrate that gaming bridges communication barriers and empowers citizens to make meaningful contributions to urban projects under the IPD framework. It can thus lead to more inclusive and successful project outcomes, fostering optimism about the proposed framework's potential benefits and instilling hope for its successful implementation.

2 Background and Literature Review

2.1 Integrated Project Delivery

IPD has evolved as a response to the fragmented nature of traditional project delivery methods, which often lead to inefficiencies and conflicts among stakeholders. The concept of IPD emerged in the early 2000s, aiming to bring all key participants—including owners, architects, engineers, and contractors—together from the project's inception through completion. This collaborative approach seeks to align stakeholders' interests, promote transparency, and share risks and rewards (Rashed & Mutis, 2023). The evolution of IPD has been marked by an increasing emphasis on collaboration and the integration of digital technologies, such as Building Information Modeling (BIM), to enhance communication and efficiency (Hwang et al., 2020).

One of the primary benefits of IPD is enhanced collaboration, which leads to improved project outcomes such as reduced waste, shorter project durations, and lower costs. As a tool for community engagement, gaming plays a significant role in promoting this collaboration, making all stakeholders, including citizens, feel engaged and involved in the project. (Mesa et al., 2019). The early involvement of all stakeholders ensures that potential issues are identified and addressed promptly, facilitating smoother project execution. Additionally, the shared risk and reward model, where all parties share in the project's success or failure, incentivizes all parties to work towards the common goal of project success, thereby fostering a collaborative and goal-oriented project environment. (Kahvandi et al., 2020).

Despite its advantages, IPD has its challenges. Implementing IPD can be complex and requires significant changes to traditional contractual and organizational structures. One major drawback is the need for high trust and collaboration among all participants, which can be difficult to achieve in practice (Nasrun et al., 2014). Furthermore, IPD often demands substantial upfront investment in time and resources to establish the necessary collaborative frameworks and technologies (Kahvandi et al., 2019). These factors can hinder adoption, particularly for smaller firms or projects with limited budgets.

2.2 Gaming, Serious Games and Gamification

Gaming, specifically serious games or gamification, has emerged as a state-of-the-art approach to community engagement. Serious games are designed for purposes beyond mere entertainment, such as education and behavior modification, while gamification incorporates game elements into non-game contexts to enhance engagement and motivation (Fleming et al., 2017). These methods have shown substantial potential in transforming interactions and fostering participation in community engagement.

In various fields, serious games and gamification have been extensively applied to enhance engagement and achieve specific outcomes. In the health sector, serious games have been utilized to promote mental health, improve health behaviors, and enhance professional education, demonstrating effectiveness comparable to traditional methods in improving knowledge, skills, and engagement (Gentry et al., 2019). The corporate sector has also leveraged gamification to enhance training, improve workforce engagement, and increase performance, though challenges in implementation persist due to organizational hierarchies and demographic considerations (Larson, 2020). Moreover, environmental education initiatives have employed serious games to foster pro-environmental behaviors, making users more aware of their energy consumption and encouraging sustainable practices (Morganti et al., 2017).

In educational contexts, gamification has been applied to enhance learning experiences, increase student engagement, and improve academic outcomes. These game-based learning environments positively affect motivation, concentration, and prosocial behaviors, demonstrating the versatility and effectiveness of gamification in education. (Chandross & Decourcy, 2018)

The application of serious games and gamification in the AEC sector remains limited, particularly in urban projects. The industry faces challenges integrating these technologies into traditional project delivery methods and demonstrating evidence-based outcomes to support their adoption.

3 Research Pathway

The research pathway toward the vision of IPD+C is organized based on three phases of knowledge management: Distillation, Contextualization, and Distribution/Democratization. Knowledge was chosen as the throughline of this research because the ultimate objective of co-creation is to generate knowledge, which is the critical currency that measures IPD+C's success.

- Knowledge Distillation involves extracting and refining relevant information from various sources to build a robust KG. This KG captures the essential concepts and relationships within the project, providing a structured foundation for subsequent phases.
- Knowledge Contextualization focuses on mapping the distilled information onto a gaming ontology. This process ensures that complex project data is transformed into an accessible and interactive format, making it easier for non-professional citizens to engage with and contribute to the project.
- Knowledge Distribution/Democratization aims to disseminate and collect contextualized knowledge via gaming. By integrating gameplay elements into the project delivery process, this phase empowers citizens to actively co-create urban projects alongside professionals.

Each phase builds upon the previous one, creating a cohesive framework that supports the successful implementation of IPD+C.

3.1 Knowledge Distillation

3.1.1 Knowledge Graph

KG is a powerful way to represent and organize information, allowing for a deeper understanding of complex relationships between concepts. They capture the intricate relationships between entities and their attributes, providing insights beyond traditional data models (Kejriwal, 2019).

Google search engine at its foundation is a massive KG connecting countless concepts and entities through intricate relationships, demonstrating the wide-ranging applications of this approach (Sheth et al., 2019). In infrastructure projects, a KG can serve as a valuable tool for mapping out the interconnected web of information related to the project, from technical specifications to construction logs to public sentiment.

When considering using only KG for knowledge distillation, it excels at capturing the complex network of interdependencies between vast amounts of concepts. However, a potential drawback of solely relying on KG is that they may struggle to capture the nuances and contextual intricacies present in unstructured textual data, which could limit their ability to distill knowledge from diverse sources effectively (Baclawski et al., 2021).

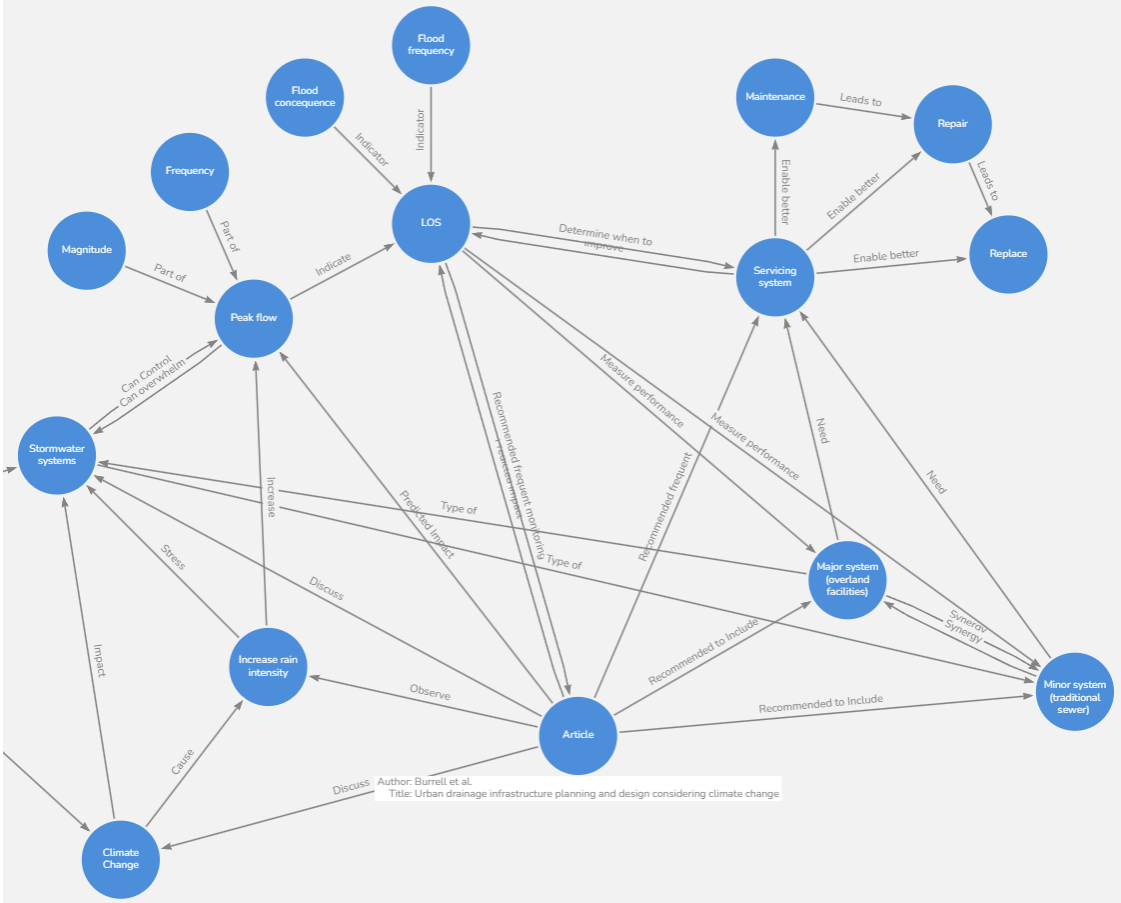

Figure 1. Sample Partial Knowledge Graph Summarizing Findings of Article

3.1.2 Large Language Models

Large Language Models (LLM) leverages advanced natural language processing techniques to interpret and generate human-like text. This enables them to rapidly distill vast amounts of textual data into a coherent summary.

These models can comprehend intricate patterns and contexts within the information they process. When applied to infrastructure projects, LLM can effectively sift through extensive documentation such as engineering reports, legal contracts, stakeholder correspondence, environmental impact assessments, project proposals, financial statements, etc., extracting and organizing critical knowledge concisely and comprehensibly.

LLM for knowledge distillation excels at uncovering intricate patterns and contexts within the information they process (Israelsen & Sarkar, 2023). However, relying solely on LLM may not fully capture explicit relationships between entities and concepts as comprehensively as KG does, potentially resulting in a loss of structured overview and interconnectivity within the distilled knowledge (Liu et al., 2024). Additionally, since the inner workings of this technology are not yet

well understood and operate like a black box, mistakes and hallucinations may occur without being detected, leading to potentially inaccurate or misleading distilled knowledge (Israelsen & Sarkar, 2023).

This paper proposes to combine KG with LLM by cross-referencing and cross-training their respective outputs. The KG is used to check for hallucinations and errors in LLM outputs, while the LLM supplements contextual and relational information during the construction of the KG. The goal is to achieve comprehensive knowledge distillation that captures explicit relationships between entities and contextual intricacies in unstructured textual data, resulting in more usable and valuable insights.

3.1.3 Bias and Contradictions

It is important to understand that no single authority or set of predetermined criteria can solely judge information's validity and value, especially when many groundbreaking ideas often straddle the line between eccentricity and brilliance. Thus, the output of the knowledge distillation system acts as a guide, providing a framework rather than definitive conclusions.

Eliminating biases or contradictions is impossible as much information is ultimately subjective; therefore, measuring and disclosing it is crucial. The evaluation of information should focus on discrimination rather than elimination to acknowledge that contradiction and divergence can lead to profound insights. This system operates under the premise that rational arguments contain elements of truth regardless of their conventional acceptance.

The essence of this research lies in its commitment to knowledge democratization, such as distributed computing, where each participant contributes to collective understanding. However, a purely democratic approach may not suffice since contributions often adhere to Pareto distribution, where a minority usually provides the most valuable contributions in any given field (Stewart et al., 2010). A weighted voting system might offer a pragmatic solution by calibrating expertise with historical contributions while maintaining inclusivity.

This paper proposes simultaneously utilizing top-down and bottom-up approaches for structured data collection. It also incorporates an empirical and distributed processing method that allows insights from feedback to emerge organically from the data (Kirrane et al., 2020). This approach promotes knowledge democratization while recognizing the impact of expertise without being overly constrained by validation systems. Balancing these factors remains one of the biggest challenges of this research.

3.2 Knowledge Contextualization

The Knowledge Contextualization phase focuses on translating complex project-related information into a format that is accessible and engaging for non-professional stakeholders. This phase ensures that the technical knowledge captured in the KG is transformed into interactive, game-based content that citizens can easily understand and interact with.

KG often contains millions of concept nodes and billions of relationship edges. As the size and complexity of the KG grows, it becomes increasingly challenging for individuals to navigate and extract meaningful insights from such a vast amount of interconnected data (Baclawski et al., 2021). This complexity can make it difficult to directly utilize the KG for communication purposes, particularly for non-technical stakeholders such as the public and diverse project team members (Santos et al., 2012).

This research proposes anchoring the KG to a suitable AEC ontology and a gaming ontology to transform knowledge distilled in the previous section into a digestible and relevant context. Ontology is a key concept in information science and knowledge representation. It provides an organized understanding of the relationships between entities and ideas within a specific domain (Dubin & Jett, 2015). Specifically designed for gaming, gaming ontologies offer a structured framework for organizing knowledge related to games, game mechanics, players, etc. While structurally similar to KG's nodes and edges, ontologies focus on defining concepts within a specific domain. KG is more flexible and can contain vast information and relationships. Expert-crafted ontology is much smaller in scale but, at the same time, more accurate and interpretable compared to KG, which is mostly algorithmically generated.

Ontologies provide a structured framework for organizing information to a specific domain, and in gaming, this means defining concepts related to game mechanics, player roles, objectives, and interactions. Mapping the concepts and relationships from the KG to a gaming ontology converts technical project details into game elements that are easy to grasp, breaking down intricate information into smaller, manageable parts that can be integrated into game scenarios. For example, technical specifications or construction logs can be represented as quests or challenges within the game.

Games inherently provide a dynamic environment where users can explore, interact, and learn. Embedding project knowledge into a gaming framework attracts citizens to voluntarily engage with the content while promoting a deeper understanding and retention. Through games, technical jargon and complex relationships are translated into visual and interactive formats, enabling non-experts to contribute their local knowledge and insights, ensuring the information exchange is bidirectional and inclusive.

An example of this contextualization might involve a construction project using a game where players take on different roles within a virtual construction site from the first-person perspective. While navigating the site, they encounter tasks and challenges corresponding to real-world project elements, such as resource management, safety protocols, or environmental impact assessments. The complexities of the representation can be adjusted to factors like audience education, purpose, and interest to optimize for knowledge generation.

Building the gaming framework involves aligning the KG with a gaming ontology to create a unified system where project data is seamlessly integrated into the game design. This includes selecting appropriate game mechanics that match the nature of the project information. The game elements are then tailored to reflect specific aspects of the project, such as contextualizing environmental impact data through a game scenario where players balance development and ecological preservation. These customized game elements form the core of the gaming experience, allowing players to interact with project data in meaningful ways, demystifying complex project aspects, and facilitating better community engagement.

3.3 Knowledge Democratization

Traditional community engagement methods often only offer token engagement or information sharing. Advanced approaches engage communities directly in decision-making processes, with professionals designing projects that integrate community needs. Finally, co-creation represents the pinnacle of community involvement, and utilizing games in this context is the cutting-edge approach. This interactive approach allows citizens to build a sense of ownership and belonging through their contributions.

The game integrates citizens into every project stage, cultivating trust. Individuals recognize that their input and feedback are valued and integrated into the project's development. The framework encourages open dialogue between professionals and citizens by using gaming as a medium for communication and co-creation. This two-way interaction bridges the gap between technical expertise and local knowledge and facilitates shifts in perspective. The transparent nature of this framework promotes goodwill, ultimately resulting in more successful outcomes for all stakeholders involved.

3.3.1 CO-Creation Through Gaming

Games are dynamic, interactive, and engaging. While playing, citizens can actively learn, problem-solve, collaborate, and co-create organically. The powerful motivation and immersion enhance user engagement and facilitate superior information retention. Moreover, games can simulate complex systems and processes, providing users with a platform to experience and interact with real-world scenarios in a controlled manner (Wiggins, 2016).

The technology of games has evolved significantly since the invention of the first video game, Pong, in 1972. Today, video games capture the attention of billions with realistic graphics, immersive virtual environments, and sophisticated AI systems that adapt to player actions. The evolution of gaming has led to its transformation into what is often referred to as the metaverse - a collective virtual shared space created by virtually enhanced physical reality and physically

persistent virtual worlds (Cheng et al., 2022). This evolution has been driven by unique qualities that make games a great medium for communication.

Figure 3. Technical Evolution of Video Games

The immersive nature allows users to enjoy a multi-sensory experience mimicking real-world interactions, making complex concepts more accessible. Games also foster collaboration, where users engage with each other through challenging scenarios, promoting effective communication and teamwork. Games are designed to have incentives that enhance user engagement, leading to better information retention; gamification techniques further motivate exploration within gaming environments, enhancing knowledge transfer. (Koivisto & Hamari, 2019). Games also have a remarkable ability to simulate complex systems and prescribe scenarios. The scenarios would play out under prescribed rules and initial conditions, allowing players to see and feel the impact of their choice in the virtual world.

Finally, games empower non-professional citizens to co-create projects and contribute to the knowledge base. Individuals actively contribute their ideas and insights by playing the game without worrying about technical considerations. This co-creation approach democratizes citizens' knowledge as they learn, contribute, and evaluate/vote for knowledge.

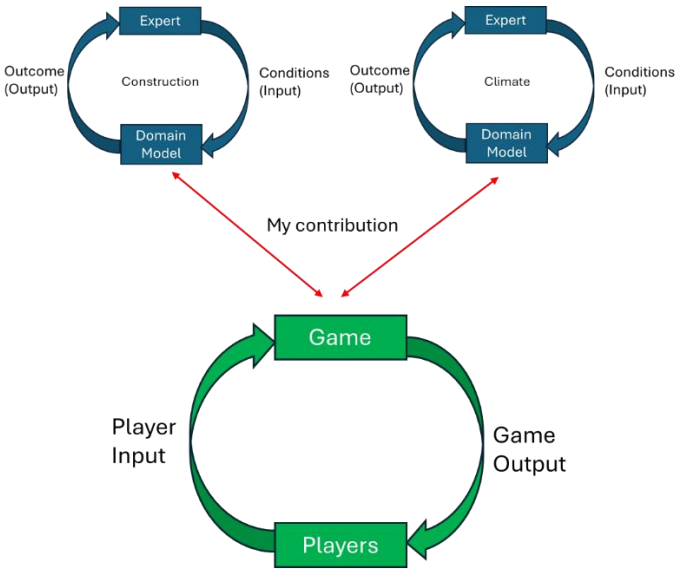

Figure 3. Domain Models Fusing Under Gaming Framework

3.3.2 Citizen Science

Citizen science involves the public in scientific research and knowledge creation, benefiting from a diverse pool of contributors. The gaming framework enhances public engagement and makes scientific concepts more accessible through interactive tasks. This framework also enables organic generation and gathering of user behavior data, fostering a deeper understanding of human behaviors. The framework democratizes access to scientific knowledge for meaningful research endeavors. Embracing co-creation processes via gaming as a service allows for integrating community knowledge and promotes fruitful collaboration between professionals and citizens in generating innovative solutions.

4 Outcome and Evaluation

The following deliverables are tools and systems necessary to integrate citizens into IPD.

- Knowledge Graph: A foundational framework for mapping and organizing diverse concepts and information from professional-citizen debates. The KG allows for a dynamic representation of key concepts, fostering a comprehensive understanding of the project's domain.
- Evolving Mechanism: An iterative process to continually refine gamified elements and interactive features based on stakeholder feedback, user engagement monitoring, and real-time data analytics.
- Gaming Ontology Integration: Developing a gaming ontology closely connected with the KG to seamlessly integrate game elements with underlying domain concepts.
- Foundational Game Repository: Establish a repository of foundational game elements to assemble more complex game systems.
- Custom Game Creator: A recommender system that leverages the insights from KG and the game repository to assemble bespoke games for a project’s unique needs.
- Empirical Evaluation of Impact: Monitoring key performance indicators relating to community engagement, knowledge creation, citizen collaboration, and project outcomes is critical to substantiating the validity and sustainability of the IPD+C framework.

5 Discussion and Future Research

This paper proposes the preliminary research pathway towards the vision of IPD+C, laying the groundwork for future investigations. It outlines the conceptual supports for integrating gaming into project delivery, and citizens as co-creators. The aim is to initiate a dialogue on the feasibility and benefits of this approach, encouraging further exploration and refinement. This paper aspires to catalyze a shift towards more collaborative and community-centered project planning in the construction industry by setting a research agenda that includes developing technical tools and methods for game-based engagement.

The paper does not dive into empirical investigation or intricate game development. Instead, it focuses on establishing the theoretical foundation that advocates for the IPD+C framework via gaming. The primary objective is to highlight the potential of gaming as a medium of co-creation, leveraging both technical and local knowledge to improve community engagement in urban projects. By positioning games as tools for enhancing communication and collaboration among stakeholders, the paper seeks to demonstrate how this novel approach can bridge existing gaps and lead to better project outcomes.

Further quantitative research will follow this foundational paper to address critical questions related to the practical implementation of the proposed framework. Future studies will explore how to construct the knowledge graph underlying IPD+C, investigate foundational game elements for the repository with respective best game design practices, and develop the recommender system that customizes games for specific projects. Additionally, these studies will evaluate the system's impact through case studies, assessing both the positive outcomes and potential drawbacks. This subsequent research aims to provide detailed, evidence-based insights that will guide the practical application of the proposed gaming framework in real-world projects.

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