# Smart City Design for Urban Resilience: Can Gamified AR Interventions Enhance Value-in-Being?*

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**Abstract**
This research examines whether augmented reality (AR) and gamification can foster dwelling and immersive experiences in smart cities, thereby enhancing value-in-being (VIB). Grounded in the VIB paradigm, the authors argue that AR interventions, by evoking contextual enhancements, can enhance dwelling (feelings of belonging, meaning, and authenticity) and immersive experiences while gamification moderates their impact. Based on a between-subject scenario experiment with repeated measures and a difference-in-differences analysis, this study provides preliminary insights for urban planners and policymakers on how to enrich urban environments, ultimately enhancing VIB and fostering urban resilience.

**Keywords**
augmented reality, dwelling, gamification, smart cities, urban resilience, value-in-being

## 1. Introduction

Urban resilience—understood as a city's capacity to navigate risks and opportunities by managing resources [2,20,43]—is often linked with physical infrastructure. However, its true foundation lies in the value that residents derive from their immediate surroundings, which contributes to residents well-being at the individual level and urban resilience at the aggregated level.

So-called smart cities—where stakeholders collaborate to enhance system efficiency, engagement, and quality of life[34]—rely heavily on technologies, particularly augmented reality (AR)[29], to foster well-being by modernizing urban spaces and enhancing residents' experiences [2]. Immersive technologies aim to create rich, culturally layered experiences in public spaces. A popular approach to boost AR's capacity to facilitate more engaging experiences is gamification[5,14]. Understood as the use of game design elements in non-game contexts[6], gamification has the potential to enhance residents' engagement with AR interventions[38] to foster experiences that enhance interactions with urban spaces.

This research is guided by the emerging design paradigm of value-in-being (VIB), which represents an alternative to the value-in-use concept[2]. It describes a more comprehensive, systemic understanding of value co-creation. It is particularly useful to emphasize the importance of experiential value in urban spaces for resident's well-being. VIB shifts the focus from merely optimizing a city's physical and operational aspects to enhancing the lived experiences of its residents. Based on the VIB paradigm, we argue that AR experiences operate through dwelling—a state of being rooted in and connected to one's environment, enabling a meaningful existence[2]—and immersive experiences—a state of deep engagement with one's surroundings[1]—in enhancing

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VIB. Collectively, enhancing residents' VIB contributes to fostering a more resilient urban environment[29].

In this research, we explore how to facilitate dwelling and immersive experiences by integrating AR and gamification in the context of smart cities. To achieve this, we focus on examining AR interventions in a smart city environment through a controlled scenario experiment, assessing their effectiveness in fostering dwelling and immersive experiences in urban spaces that ultimately support VIB. Additionally, we aim not only to validate the technical feasibility of integrating AR and gamified experiences in smart city development but also to provide valuable insights into their impact on enhancing dwelling experiences, VIB, and, by extension, urban resilience on an aggregated level.

This study contributes to the evolving field of smart city development by examining how integrating AR with gamification can facilitate dwelling and immersive experiences, ultimately enhancing VIB in urban environments. Shifting focus from functional benefits to the creation of engaging and contextually relevant experiences, this research aims to advance understanding of the hallmarks of smart city design. The contribution of this research lies in providing a novel framework for urban planners and policymakers that prioritizes VIB.

## 2. Conceptual Framework

### 2.1. Research Model

The research model (see Figure 1) links AR experiences—designed to evoke either cultural narratives or contextual enhancements—to dwelling experiences and, ultimately, VIB. Gamified experiences serve as a moderating variable, shaping the effect of AR experiences on dwelling and immersive experiences and their subsequent impact on VIB. In the following, we provide a rationale for the proposed relationships and detail the components included in the research model.

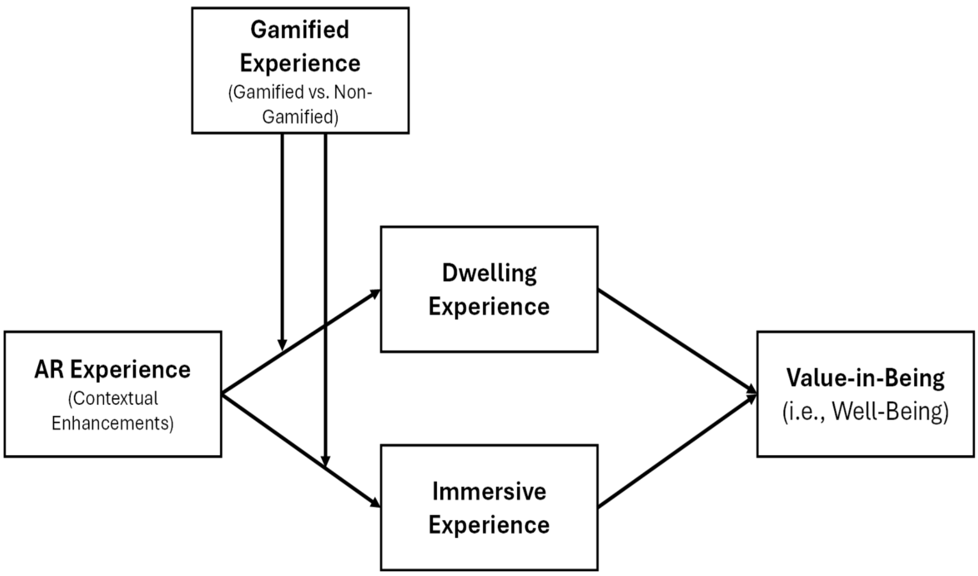


**Figure 1:** Research Model

As mentioned above, we base our research model on the recently introduced VIB paradigm and apply it to the context of smart cities. The VIB paradigm stems from service research and focuses on identifying interconnected elements and establishing the context of one's (service) environment that enables customers to achieve a state of dwelling, expanding their awareness of the service experience beyond purely functional benefits [2].

In the context of our research, AR technology represents an enabler that reveals the interconnectedness within one's environment. For instance, in the context of smart cities, AR interventions can immerse residents by overlaying contextual information[3]. Previous VIB research suggests that dwelling arises from experiences that are perceived as meaningful, and authentic while also fostering a sense of belonging within one's environment. Dwelling experiences connect residents to an urban area's narratives and lead to a richer, more holistic awareness of their surroundings, which is associated with increased VIB[2]. Immersive experiences, on the other hand[1], can be triggered through highly engaging interventions[38].

In sum, the research model implies that AR experiences (rooted in contextual enhancements) directly influence dwelling and immersive experiences by fostering connections to the environment. Dwelling and immersive experiences, in turn, mediate the relationship between AR experiences and VIB, as the sense of rootedness and belonging derived from these interactions contributes to residents' well-being. Gamified experiences act as a moderating variable, shaping how AR experiences enhance dwelling and immersion by adding engaging elements that might amplify connection, belonging, and engrossment. Together, these relationships highlight the interplay of technology, environment, and interaction in creating meaningful, value-driven outcomes in smart urban environments. In the following sections, we provide the conceptual background for the constructs included in the research model.

## 2.2. Dependent Variable: Value-in-Being

VIB represents a paradigm shift in value co-creation, focusing on the meaningfulness and emotional interconnectedness of existence rather than utilitarian goal attainment[2]. Rooted in Heideggerian philosophy[15], it emphasizes the integration of tangible and intangible elements in one's environment and the process of meaning-making to foster immersive and authentic experiences. Unlike the transactional nature of value-in-use, VIB arises from dwelling within the broader service ecosystem, engaging with cultural, social, and environmental dimensions. This concept highlights the importance of meaningful experiences in service design, enabling individuals to derive well-being from their interactions within their environment. It shifts the focus from functional utility to creating a holistic sense of belonging and purpose in an individual's daily life.

Following prior VIB research[2], we conceptualize VIB as the value residents derive from being connected to their surrounding. In the context of AR experiences in smart cities, VIB reflects the profound sense of connection and purpose individuals gain from technology-driven interactions that seamlessly integrate digital and physical environments, fostering a deep sense of belonging to the urban space. These experiences transcend the mere functional benefits of technology, creating an enriched and rooted state of being that enhances residents' well-being. In what comes next, we describe dwelling and immersive experiences as antecedents of VIB[2].

## 2.3. Mediating Variables

### 2.3.1. Dwelling Experiences

Dwelling experiences, as conceptualized within the Heideggerian framework, are characterized by sustainability, rootedness, and a profound connection to one's environment[2]. These experiences represent an ongoing process of interconnections with tangible and intangible elements in the environment. Unlike the functional focus of value-in-use-oriented technology design, dwelling experiences guide technology design by considering how technology interactions can foster emotionally connected and meaningful existence. They involve emotional and cognitive presence, sparking a sense of belonging and ecological preservation. Dwelling experiences not only anchor individuals in their environment but also facilitate the co-creation of value-in-being by enabling reflective and authentic engagement with their surroundings.

Dwelling experiences comprise three key dimensions: belonging, meaning, and authenticity. *Belonging* forms the foundation where individuals feel integrated into their environment, fostering a sense of safety, community, and emotional resonance that enhances their capacity for well-being[2]. *Meaning* arises through the active process of making sense of one's environment by uncovering its interrelated structures and histories[35]. By connecting to the broader interconnectedness of the intangible and tangible elements in one's environment, individuals derive purpose and significance from their experiences. Finally, *authenticity* ensures that these experiences are genuine and aligned with intrinsic values and the higher purpose of the environment[15]. Authenticity reinforces the depth and credibility of dwelling experiences, ensuring that they resonate meaningfully with individuals. Together, these dimensions reflect dwelling experiences that enrich human existence and enhance well-being.

### 2.3.2. Immersive Experiences

*Immersive experiences* involve deep engagement with one's surroundings, where consciousness is fully absorbed into the urban space, enabling seamless and transformative interactions[1,8]. These experiences create a captivating sense of presence and engrossment[8], blurring the lines between the physical and digital worlds, fostering a stronger connection to the environment. Moreover, they can significantly influence residents' perceptions, turning routine urban interactions into memorable, impactful encounters that enhance personal well-being.

## 2.4. Augmented Reality

In terms of the AR technology deployed in this research, we focus on AR cloud (ARC) applications that leverage traditional AR features (e.g., digital overlays in real-world environments)[16,30] to facilitate experiences of the transitory metaverse—that is, real-time interactions and collaboration, high content flexibility, contextual awareness, and personalized experiences[3,44].

ARC represents an evolution of AR and lifelogging, which involves capturing (i.e., storing, and sharing experiences and information from the physical world), integrating real-time contextual awareness, decentralized content creation, dynamic personalization, and immersive engagement into a unified digital-physical ecosystem[3,27]. It builds on AR's spatial capabilities (i.e., spatial AR) to offer multilayered interactions where users can access continuously updated content[33]. Unlike static AR applications, ARC relies on decentralized control, allowing for value co-creation and empowering users to actively contribute in shaping their digital environments and AR experiences [9,17]. ARC also enables personalization of features to further enhance experiences by dynamically adapting to preferences while maintaining a balance between customization and privacy concerns[3]. Additionally, ARC excels in fostering authentic interactions by enabling real-time collaboration, overcoming the linear nature of content in traditional AR, and adding a dynamic layer [3]. By merging lifelogging's immediacy with AR's immersion, ARC offers a holistic approach to integrate experiences of the transitory metaverse (see above).

## 2.5. Moderator: Gamification

### 2.5.1. Motivational Experiences of Gamified Services

In this resarch, we examine gamified interactions in smart city environments through the lens of motivational user experiences—namely, social comparison, self-development, social connectedness, expressive freedom[5,14,38,40-42]—arising from using non-game AR interventions enhanced with game design elements (e.g., leaderboards, badges)[6,19]. This is because prior research argues that the effectiveness of gamification stems from the experiences it provides during service consumption[5,14,19]. Several literature reviews on gamification conclude that the enhanced experiences stemming from game design elements represent motivational drivers of the activities underlying the gamified service. For instance, Sheffler et al.[32] found in a large-scale field experiment involving a gamified biking commuting program that social sharing as part of the reward badge design (i.e., experiencing social connectedness) is related to increased ridership.

Literature differentiates four engaging motivational experiences arising from interacting with gamified services: social comparison, self-development, social connectedness, and expressive freedom[5,25,42]. *Social comparison* is understood as perceptions of competition evoked, for instance, from benchmarking one's own achievements against those of others[40]. *Self-development* refers to experiences of achievement, being challenged through the activity itself (not by others), and making progress, which can result from the continued development of abilities and skills[5]. *Social connectedness* reflects experiences of social interaction and cooperation resulting from the formation of interpersonal attachments[40]. Lastly, *expressive freedom* is characterized by experiencing free choice and self-expression during technology use, allowing individuals to act in their own interest with a lot of autonomy[42].

### 2.5.2. Literature Review on Gamification in Urban Development

As we aim at creating implications for urban development, we now discuss the emerging research on deploying gamification to tackle urban challenges. Previous studies in this stream highlighted gamification's potential to address urban planning challenges. For instance, a study on the Beta Blocks initiative in Boston has demonstrated how gamified prototypes can empower local communities to influence urban technology deployment, evoking social connection through collaborative governance[12]. Another study examined how gamification can deploy experiences of self-development to address post-COVID-19 urban challenges, such as managing public spaces through wayfinding and social distancing games, thereby promoting health and resilience[4].

Moreover, researchers have developed frameworks like Anagenesis[36] and Game.UP[28] to further underscore gamification's role in transforming hierarchical urban governance into participatory systems, leveraging playful and interactive tools to motivate public involvement and ensure democratic urban design. These studies indicate that gamification can make urban technologies more human-centric and enhance their experiential value, bridging gaps between technological systems and the VIB paradigm [29,39]. Despite these advancements, the integration of AR experiences and gamification and how it is related to dwelling experiences and VIB still remains understudied.

## 3. Methodology

### 3.1. Setting and Experimental Design

We conducted an online scenario experiment using a between-subject 2 (AR: contextual enhancements present vs. absent) × 2 (gamification: gamified vs. non-gamified) factorial design, incorporating a control group (no AR, non-gamified) with repeated measurements. As we intend to conduct a difference-in-differences (DID) analysis (see below), we measured the focal mediating and outcome variables both before and after the treatments to evaluate changes in participants' dwelling and immersive experiences as well as VIB. This approach allows us to isolate and quantify the incremental impact of each treatment by comparing changes in outcomes over time between the treatment groups and the control group.

In line with previous research[37], we recruited 155 participants through Prolific for the online scenario experiment in return for a nominal payment. We situate our study in Dubai, a city at the forefront of smart city innovation due to the United Arab Emirates' rapid urbanization and technological progress[22]. Initially, all participants were exposed to a control scenario, which simulated standing in front of the Burj Khalifa in Dubai with a smartphone displaying smart city details related to the tower from Wikipedia. This control scenario facilitated the pre-treatment measurement, where, following an attention check, participants responded to items measuring dwelling and immersive experiences, as well as VIB.

Subsequently, participants were randomly assigned to one of the following three groups:

(1) **Control Group**: Repeated exposure to the control scenario.

(2) **AR Experience Group**: Exposure to a scenario overlaying smart city details on the smartphone screen's camera picture to trigger AR experiences.

(3) **AR and Gamified Experience Group (Moderator)**: Exposure to the AR scenario supplemented with gamified elements including a badge, a pathfinder, and a progress bar to trigger self-development as a motivational experience.

The information across the three scenarios was kept constant. After processing these scenarios, participants completed the same set of items as in the pre-treatment measurement to assess post-treatment measurements of the mediating variables (dwelling and immersive experiences) and the outcome variable (VIB). This design allows for the examination of changes in participant responses due to triggering AR and gamified experiences, isolating the effects of these manipulations. All materials are provided in Figures 2 - 4.

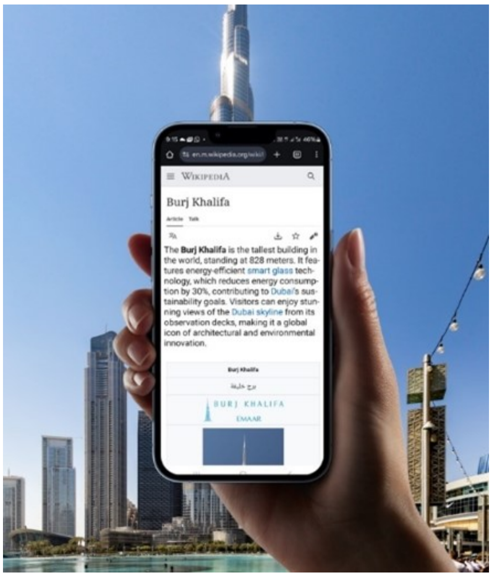


**Figure 2:** Control Scenario


**Figure 3:** Control Scenario


**Figure 4:** Gamified AR Scenario

### 3.2. Measures

We measure all construct items using a 7-point Likert scale, anchored by 1 = "Strongly disagree" and 7 = "Strongly agree". Given that the VIB paradigm has only recently been introduced to the marketing literature[2], a scale to measure its key outcome (i.e., VIB) has yet to be developed. To address this, we rely on established well-being scales to approximate VIB. Specifically, we follow Wolf et al.[40] and measure well-being using four items adapted from Diener et al.[7] to assess life satisfaction, and three items adapted from Ryff[31] to capture personal growth. We adapted these items to match the context of our experimental study to measure the dependent variable of our research model (see Table 1). Factor analysis revealed that the items of both constructs load onto one single factor (all factor loadings > 0.74; Eigenvalue = 5.14; variance explained = 96.53%). To facilitate interpretability, we summarize it by calculating one mean score for the subsequent analysis. Cronbach's alpha ($\alpha$) indicates construct reliability ($\alpha$ = 0.95).

**Table 1**
Measurement of Well-Being (Dependent Variable)

| Dimension | Item |
|---|---|
| Life satisfaction | Such experiences make me feel my life is closer to my ideal. |
| | Such experiences improve the conditions of my life. |
| | I feel more satisfied with my life after such experiences. |
| | Such experiences help me achieve the important things I want in life. |
| Personal growth | Such experiences expand my horizons and contribute to my personal development. |
| | Such experiences help me recognize ways I could improve as a person. |
| | Such experiences help me to continuously learn, change, and grow. |

To capture dwelling experiences, we deploy a self-developed scale encompassing its three dimensions—belonging, meaning, and authenticity—as suggested by Alimamy et al.[2]. Factor analysis results indicate that the items of the three dimensions load onto one single factor (all factor loadings > 0.69; Eigenvalue = 5.69; variance explained = 92.73%), with high reliability ($\alpha$ = 0.95). We measured immersive experiences using items adapted from Agarwal and Karahanna[1; $\alpha$ = 0.93]. We again take the mean scores for later analysis. The measurement items of dwelling and immersive experience are depicted in Table 2.

### 3.3. Difference-in-Difference Analysis

The goal of this research is to understand how triggering AR and the addition of gamified experiences influence resident's dwelling and immersive experiences and VIB in turn in a smart city context. We follow prior research[11,13,26] and deploy the DID approach. This approach allows us to compare changes in the experiences of participants exposed to AR and gamification (treatment groups) against those who were not exposed to these features (control group) from before until after the treatments.

We leverage the DID approach in this research because it allows us to isolate the changes in dwelling and immersive experiences as well as VIB after establishing a consistent baseline using the control scenario across all participants and then exposing some participants to the treatment conditions. DID modeling enables us to estimate an unbiased treatment effect, assessing whether exposure to AR and gamification leads to significant changes in dwelling and immersive experiences compared to the control group.

**Table 2**
Measurement of Dwelling and Immersive Experiences (Mediating Variables)

| Construct (Dimension) | Item |
|---|---|
| Dwelling (Belonging) | I felt a deep connection during the experience. |
| | The experience gave me a sense of belonging. |
| | The experience fostered a feeling of community. |
| Dwelling (Meaning) | The experience was meaningful to me. |
| | The experience aligned with my personal values. |
| | The experience reflected my interests and lifestyle. |
| Dwelling (Meaning) | The experience genuinely reflected the city's core values. |
| | The experience felt authentic and true to its purpose. |
| Immersion | I felt so involved in the experience that the outside world faded away. |
| | I was fully immersed in the experience. |
| | The experience allowed me to take a break from everyday life. |

The rationale behind DID is to control for all time-invariant differences between the treatment and control groups, as well as any trends over time that affect both groups equally. To do so, we first need to construct a time variable $Time_{it}$, which takes on the value of 0 before the treatment (i.e., AR-treatment with or without gamification elements) and 1 after the treatment for *all* participants (i.e., reflecting the two time periods in our study). This time variable captures any general trends affecting both the treatment and control groups across the two time periods in our scenario experiment.

Second, we need to construct the variable $AR\text{-}treatment_i$, which is a binary indicator variable that captures whether a participant is in the treatment group (1; exposed to AR) or in the control group (0; not exposed to AR). Likewise, we create the variable $Gamification_i$, which takes on the value of 1 when a participant was exposed to the gamified AR-treatment and 0 when not.

Third, the equations modeling the treatment effects need to include two interaction terms: $Time_{it} \times AR\text{-}Treatment_i$ and $Time_{it} \times AR\text{-}Treatment_i \times Gamification_i$. The first interaction term models the differential effect of being in the AR-treatment group after the intervention is introduced, compared to before the treatment and relative to the control group. The second interaction term enables the model to estimate the effect of the second treatment—that is, gamification in addition to AR, It is worth noting that this effect is nested in (or layered on top of) the first AR-treatment effect. This allows us to quantify the additional impact of enhancing the AR treatment with gamification over time. Importantly, the main effects of $AR\text{-}Treatment_i$ and $Gamification_i$ cannot be estimated directly, as they always take on the value of 0 in the control group.

As we aim to examine the treatment effects on both dwelling and immersive experiences, it is necessary to estimate a separate equation for each, incorporating the variables and interactions previously outlined. Additionally, we are interested in exploring how dwelling and immersive experiences influence VIB. This leads to the following equation system:

(1) $Dwelling_{it} = \beta_0 + \beta_1 Time_{it} + \beta_2 Time_{it} \times AR\text{-}Treatment_i + \beta_3 Time_{it} \times AR\text{-}Treatment_i \times Gamification_i + \epsilon_{it}$

(2) $Immersion_{it} = \gamma_0 + \gamma_1 Time_{it} + \gamma_2 Time_{it} \times AR\text{-}Treatment_i + \gamma_3 Time_{it} \times AR\text{-}Treatment_i \times Gamification_i + \nu_{it}$

(3) $Value\text{-}in\text{-}Being_{it} = \lambda_0 + \lambda_1 Dwelling_{it} + \lambda_2 Immersion_{it} + \mu_{it}$

with $\epsilon$, $\nu$, and $\mu$ representing the error terms.

### 3.4. Method

The above mentioned equation system requires an analysis method that accounts for potentially correlated error terms across the equations. We therefore follow prior literature[23-24] and employ the seemingly unrelated regressions (SUR) method[45]. SUR allows for efficient parameter estimates by accounting for potential correlations among error terms across different regression equations. This approach is particularly advantageous considering the relationships proposed in our research model, where dwelling and immersive experiences represent dependent variables in one equation respectively but become independent variables in another equation. As a result, each equation's error term may not be independent[21]. The use of SUR, as opposed to separate ordinary least squares regressions, allows for more precise estimation by exploiting the information contained in the error terms' covariance structure. A key assumption of SUR is that the errors across the equation system are correlated. A significant Breusch–Pagan test of independence ($\chi^2 = 193.061$; $p < 0.001$) strongly rejects the null hypothesis of independent equations. This provides evidence that it is appropriate to apply the SUR method.

## 4. Results

The central identifying assumption of the DID model is the parallel trends assumption, which posits that, aside from the intervention, the treatment and control groups should follow similar trends over time [10]. This means that any differences between pre- and post-treatment measurements (e.g., participant fatigue; [18]) in both the AR and gamified AR groups, compared to the control group, can be attributed solely to the treatment effect. To ensure whether the parallel trends assumption is met, we plot the average dwelling and immersion values before and after the AR-treatment for the treatment and AR groups (see Figure 5). The plot reveals similar trajectories in average dwelling and immersion values for both the AR treatment and control groups before and after the treatment, suggesting that the parallel trends assumption is met.

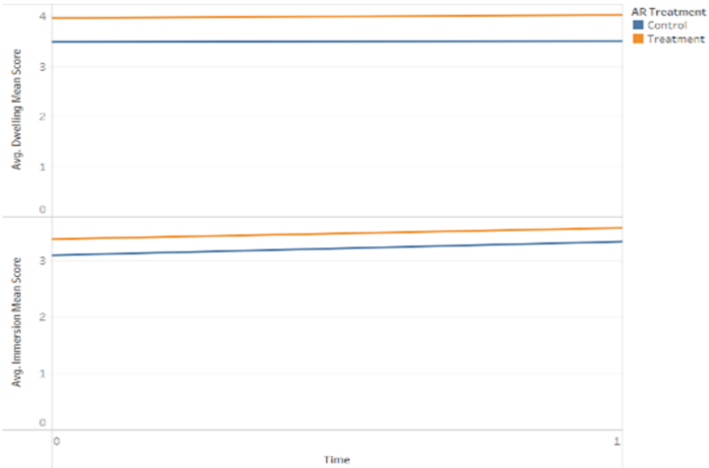


**Figure 5:** Visual Inspection of Parallel Trends in Dwelling Times Pre- and Post-AR-Treatment

We display the results of the SUR estimation in Table 3. The results reveal a significant effect of the AR-treatment on dwelling experiences ($\beta_2$ = 0.61, $p$ < 0.05), indicating that AR exposure enhances dwelling experiences compared to the control group. Interestingly, adding gamification to the AR-treatment does not significantly strengthen this effect ($\beta_3$ = −0.17, $p$ = 0.549). We do not find any significant effects of the AR-treatmeant or the gamified AR-treatment on immersive experiences (all $p$ > .400). Lastly, as expected, the results demonstrate that both dwelling ($\lambda_1$ = 0.59, $p$ < 0.001) and immersive experiences ($\lambda_2$ = 0.26, $p$ < 0.001) experiences significantly increase VIB.

## 5. Discussion

In line with the VIB paradigm, the results provide evidence that dwelling and immersive experiences significantly enhance VIB, confirming their importance in smart city contexts. However, while AR improved dwelling experiences, it did not have a significant impact on immersive ones. Surprisingly, adding gamification elements to AR experiences did not enhance either dwelling or immersive experiences. One possible explanation for these findings is the limitation imposed by the online format of the experiment, which may not have effectively captured the interactive and engaging potential of AR and gamification. The nonsignificant effects of the treatments on immersive experiences further point to this alternative explanation.

Given these insights, future research should consider employing actual AR technologies, potentially using virtual reality glasses, to create a more interactive experience. This approach would allow researchers to explore the full potential of AR and gamification in enhancing resident experiences within smart city environments. By leveraging real-world AR technologies and letting participants engage with gamification elements, future studies could more realistically simulate smart city settings.

**Table 3**
Estimation Results

| Variable | Coef. | SE |
|---|---|---|
| **DV: Dwelling Experiences** | | |
| Constant | 3.81*** | 0.11 |
| Time | −0.31 | 0.23 |
| Time × AR-Treatment | 0.61* | 0.28 |
| Time × AR-Treatment × Gamification | −0.17 | 0.28 |
| **DV: Immersive Experiences** | | |
| Constant | 3.29*** | 0.13 |
| Time | 0.05 | 0.26 |
| Time × AR-Treatment | 0.26 | 0.32 |
| Time × AR-Treatment × Gamification | −0.29 | 0.32 |
| **DV: Value-in-Being** | | |
| Constant | 0.63*** | 0.15 |
| Dwelling | 0.59*** | 0.06 |
| Immersion | 0.26*** | 0.05 |

Notes: * $p < 0.05$;** $p < 0.01$;*** $p < 0.001$. DV = dependent variable. N = 310 (155 × 2 periods).

Based on our results, it is evident that AR can enhance urban resilience, demonstrating its potential to improve engagement and interaction within urban environments. However, our findings suggest that gamification, specifically when based on elements aimed at triggering self-development, does not yield the same benefits. This suggests that the chosen gamification elements may not align with the context of urban settings. Future research could explore other motivational experiences stemming from gamification, such as social comparison or cooperation [40] to identify how gamification can contribute to urban resilience.

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