

Evaluating a Game-based Workshop for Youth Urban Design Using Open-source Tools

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Abstract: Game-based learning (GBL) has shown promise for engaging citizens in participatory urban planning, with Minecraft-based initiatives such as UN-Habitat's Block by Block programme reaching over 55 countries. However, evaluations of these initiatives remain predominantly qualitative, and few studies combine pre/post statistical testing with behavioural process data. In Japan, participatory urban planning follows the tradition of machizukuri, a bottom-up approach to community-driven town-making that has progressively incorporated design games and digital tools, yet rarely targets younger populations with rigorous outcome measurement. This paper presents the design, implementation and mixed-methods evaluation of an open-source game-based workshop for youth participatory urban design. The workshop integrates Japan's national 3D city model data (MLIT's PLATEAU), the Blender modelling environment and the Godot game engine into a mission-based co-design activity in which students redesign a real public park. Unlike Minecraft-based approaches, it uses real geospatial data at actual scale, supports both design-time placement and first-person exploration, and relies exclusively on free software. Fifty sixth-grade students (aged 11–12) at a public elementary school in Yokohama, Japan, participated in groups of 3–5. Five data streams were collected: pre/post Likert surveys (n=36 paired), post-only items, conversation transcription and classification (21,612 words across 12 groups) and map annotations (n=17) with open-ended responses (n=34). In this single-group design, Wilcoxon signed-rank tests indicated increases in civic participation willingness ($p < 0.001$, paired $d = 0.66$), career interest in urban design ($p < 0.001$, $d = 0.89$) and interest in the target site ($p = 0.017$, $d = 0.35$), while perceived tool difficulty did not change; the first two results remain significant under Bonferroni correction, the third does not. Conversation analysis showed a shift from operational to design-oriented discourse (chi-square, $p < 0.001$, Cramér's $V = 0.17$), the design-to-operation ratio rising from 0.82 to 1.96. Post-only items showed 90.9% agreement that the game mode was exciting. Because the study included no control group and students worked in clustered groups, these results describe short-term associations rather than causal effects. The study nevertheless demonstrates the value of multi-modal evaluation for small-sample serious game interventions.

Keywords: Game-based learning, Machizukuri, Participatory urban design, Godot engine, PLATEAU

1. Introduction

Engaging young people in shaping their built environment is both a normative ideal and a practical challenge for planning, education and civic governance. In Japan, participatory urban planning has long been structured around machizukuri, a bottom-up tradition emphasising collaboration among residents, professionals and local institutions (Satoh, 2020). Originating as a counterpoint to top-down urban renewal in the 1960s, it has progressively incorporated new tools, from neighbourhood walks and scale models to digital mapping and design games (Satoh, 2015; Ando, 2024). Yet youth remain underrepresented in machizukuri processes, and few initiatives evaluate the learning outcomes of digital participatory tools with young participants.

Game-based learning (GBL) has meanwhile gained traction in educational research as a means of fostering engagement, knowledge acquisition and skill development through structured play (Plass et al, 2015). In urban planning, Minecraft-based workshops, most notably UN-Habitat's Block by Block programme, have supported community co-design in more than 55 countries (UN-Habitat, 2021). Evaluations of these initiatives nevertheless remain largely qualitative, relying on self-reported impressions rather than standardised instruments (Szot, 2024). Enthusiasm for such approaches is well documented; rigorous evidence of their cognitive, attitudinal and civic impacts is not.

This paper addresses that gap through the design, implementation and multi-modal evaluation of a game-based machizukuri workshop conducted with 50 sixth-grade students (aged 11–12) at a public elementary school in Yokohama, Japan. The workshop combines MLIT's PLATEAU 3D city model data, Blender for asset preparation and the Godot game engine, using real geospatial data at actual scale and relying exclusively on free software.

This paper makes three contributions: a reproducible open-source workshop framework bridging machizukuri practice and game-based pedagogy; a mixed-methods evaluation combining pre/post surveys, automated conversation analysis, placement logging and qualitative data; and a discussion of the methodological implications of small-sample, single-group GBL evaluation, including non-parametric testing, multiplicity and

clustering. Three research questions are addressed. RQ1: does a single session coincide with measurable short-term changes in students' civic and vocational attitudes? RQ2: does group discourse shift from tool operation towards design reasoning? RQ3: how do students experience the toolchain, and which usability barriers constrain it?

2. Literature Review

2.1 Machizukuri and Gamification in Japanese Urban Planning

Machizukuri (literally “town-making”) encompasses the community-driven processes through which citizens influence the built environment and the quality of everyday life (Satoh, 2020). Across its three generations (Satoh, 2019) it has incorporated participatory design games, physical models and role-playing methods (Satoh, 2015; Thiel and Fröhlich, 2017). Ando (2024) recently systematised the use of board games in machizukuri workshops, showing how gameplay can foster empathy and sustained engagement.

Digital machizukuri initiatives have multiplied, often drawing on PLATEAU, the open-data programme of the Ministry of Land, Infrastructure, Transport and Tourism (MLIT), which provides 3D city models for more than 200 Japanese cities (Seto et al, 2023). Use cases include gamified workshops using Cities: Skylines with high school students in Hokota City, where over 90% of participants reported increased interest in community planning (MLIT, 2023). Minecraft-based workshops have also been conducted, sometimes using PLATEAU data for the base model (Nishi and Aiba, 2022). Such initiatives typically employ proprietary tools and report outcomes through post-only surveys without baselines.

2.2 Game-based Learning and Serious Games in Urban Design

Game-based learning rests on the premise that digital and analogue games can serve as environments for knowledge acquisition, skill development and learner engagement (Prensky, 2003; Plass et al, 2015). In urban planning, serious games range from simulations such as SimCity (Adams, 1998; Minnery and Searle, 2014) to mini-games designed for specific planning objectives (Devisch et al, 2017). Kavouras et al (2023) proposed a low-cost methodology combining open datasets, user-generated content and game engines. The EquiCity game (Nourian et al, 2024) combines Markovian design, fuzzy logic and graph theory for participatory spatial configuration, while de Sena et al (2025) developed the Playful Participatory Planning System (P-PPS), which transforms Minecraft player actions into analysable geospatial data and was tested with 58 schoolchildren in Ireland.

Despite this growing body of work, a systematic review by Din et al (2023) found that questionnaires and pre/post procedures dominate serious game evaluation, yet standardised instruments are rarely employed. Alotaibi (2024), in a systematic review and meta-analysis restricted to early childhood education, reported moderate-to-large effects of GBL on cognitive, social, emotional and motivational outcomes, while noting that gaps in the evaluation literature remain to be addressed.

2.3 Spatial Thinking and Youth Participation

Spatial thinking encompasses the cognitive processes by which individuals perceive, conceptualise and manipulate spatial relationships (Hegarty et al, 2006), and video games can enhance capacities such as mental rotation and visual attention (Spence and Feng, 2010); gains in spatial reasoning have been reported among schoolchildren using digital games (Yang and Chen, 2024; Liu et al, 2025). Youth participation in planning has meanwhile evolved from tokenistic involvement towards genuine power-sharing (Hart, 1992; Checkoway, 2012), access to public space shaping young people's sense of belonging (Kinoshita, 2007), while maker-centred learning (Clapp et al, 2016) seeks to equip youth to see themselves as active shapers of their environments.

2.4 Game Engines for Planning Visualisation

Game engines have been identified as tools for environmental and landscape planning since the early 2000s (Herwig and Paar, 2002), offering real-time 3D visualisation at low cost, and later work demonstrated their potential for architectural design games (Westre, 2013) and for interactive visualisation of geospatial data (Laksono and Aditya, 2019; Keil et al, 2021). Godot, released in 2014, was the first comprehensive open-source engine supporting both 2D and 3D development (Holfeld, 2024); its lightweight architecture, cross-platform deployment and absence of licensing fees suit educational and civic applications with limited resources. Godot has no official PLATEAU SDK, unlike Unity and Unreal Engine, and the pipeline presented here fills this gap using Blender as an intermediary.

Taken together, this body of work displays three recurrent evaluation weaknesses. First, reported outcomes rest predominantly on post-only self-report, so pre-intervention baselines are unavailable (UN-Habitat, 2021; MLIT, 2023). Second, effect sizes, assumption checks and the treatment of ordinal data are seldom reported, which prevents cumulative synthesis (Din et al, 2023). Third, process data documenting what learners do and say during play are rarely collected alongside outcome data, the spatial logging of de Sena et al (2025) being a notable exception. The study below responds to these weaknesses by combining a pre/post design with automatically captured process data, and by reporting effect sizes, assumption checks and the limits the sample imposes on inference.

3. Methodology

3.1 Technology Pipeline

The workshop employs a three-stage open-source pipeline. First, 3D city model data for the target site (Takashima Central Park and its surroundings in Yokohama's Minato Mirai district) was acquired from MLIT's PLATEAU dataset in CityGML format. Second, the data was imported into Blender for cleaning, mesh simplification, semantic layer structuring and export to GLTF. Third, the cleaned model was integrated into Godot with a custom plugin enabling drag-and-drop placement of pre-curated 3D assets (urban furniture, vegetation, play equipment) from the Kenney library, released under the CC0 public domain dedication. A character-controlled mode allows participants to explore their designs in first-person or third-person perspective.

3.2 Workshop Structure

The workshop was conducted on December 17, 2025, in an elementary school in Yokohama, with approximately 50 sixth-grade students (aged 11–12) organised into 12 groups of 3–5, each supported by one university student facilitator. Each group worked with one computer, with a designated operator rotating among members. Because students shared a computer, a facilitator and a task, the group is the natural unit of clustering, as discussed below. Ethical procedures governing approval, consent, assent, recording and anonymisation are set out in the Ethics Declaration.

The activity had two phases. The pre-mission was a technical onboarding exercise in which groups placed benches and tables for a family of four, practising asset selection, movement, rotation and placement. The main mission asked groups to redesign the park to be more inclusive and welcoming for diverse users, considering age, gender, nationality, accessibility, safety and enjoyment; it was co-designed with the school principal to align with the school's charter on diversity and community awareness. Each group then presented its design to the class.

3.3 Data Collection

Four data streams were collected to enable multi-modal evaluation.

3.3.1 Pre/post survey

A four-item Likert questionnaire (1–5) was administered before and after the workshop: Q1 measured willingness to participate in community events; Q2 interest in urban design as a career; Q3 interest in the target site; Q4 perceived difficulty of 3D software. Of approximately 50 participants, 43 completed at least part of both questionnaires, yielding 35–36 complete paired responses per item.

3.3.2 Post-only survey items

Five further items (Q5 to Q9) and three software items (SoftQ1 to SoftQ3) were administered after the workshop only; the constructs they measure are given in Table 2.

3.3.3 Conversation data

Audio recordings of all 12 groups during the 45-minute modelling phase were transcribed and tokenised using Python and Janome (a Japanese morphological analyser). Extracted nouns, verbs, adjectives, adverbs and interjections were matched against two dictionaries fixed before the analysis: Category A, 42 operational terms denoting tool actions, interface objects and viewpoint control; Category B, 89 design terms denoting spatial elements, park functions, user groups and social qualities such as safety or accessibility.

Because classification is a deterministic dictionary lookup, it is exactly reproducible and requires no inter-coder reliability estimate; its validity depends instead on the composition of the lists, which were not revised after the

results were inspected. The dictionaries jointly matched 4,627 tokens, approximately 21% of the 21,612 transcribed words, the remainder consisting of function words, backchannels, proper names and off-task talk. Matched tokens were aggregated over three equal periods of 15 minutes.

3.3.4 Post-workshop map annotation and open-ended responses

Students were given printed maps of Takashima Central Park and asked to annotate locations and functions important for others (elderly, tourists, etc.). Seventeen responses were collected (40% return rate). Additionally, 34 free-text responses were collected and categorised thematically.

3.4 Statistical Approach

Given the ordinal nature of the data and the small sample, the Shapiro-Wilk test was applied to the pre/post difference distributions. All four items violated normality ($p < 0.01$), motivating the Wilcoxon signed-rank test rather than the paired t-test. The hypotheses were directional, since the workshop was designed to raise civic and vocational interest, so one-tailed tests are reported; the two-tailed probabilities are twice the values in Table 1 and remain below 0.05 for Q1 to Q3. Because four items were tested on the same sample, a Bonferroni-corrected threshold of 0.0125 is also applied. Effect sizes are given as the paired standardised difference d and as the rank-biserial correlation r ($Z/\sqrt{N}$); a paired d is not comparable with the between-group d of most GBL meta-analyses and is interpreted only alongside r .

For the conversation data, the association between time phase and utterance category was tested with a chi-square test on the aggregated three-by-two table, with adjusted standardised residuals and Cramér's V . Two constraints should be stated. First, the unit of analysis is the token rather than the student or group, so the effective sample size is inflated and the probability is best read as descriptive. Second, both the survey and the conversation data are clustered within the 12 groups. Cluster-robust or mixed-effects models would be the appropriate treatment, but 12 clusters of 3 to 5 members provide too little information to estimate group-level variance reliably; the clustering is therefore acknowledged rather than modelled, and the results below are treated as provisional.

4. Results

4.1 Pre/Post Attitudinal Changes

Table 1 presents the Wilcoxon signed-rank results for the four paired items.

Table 1: Pre/post comparison using Wilcoxon signed-rank tests (one-tailed)

Item	n	Pre M (SD)	Post M (SD)	Δ	W	p	d	r
Q1: Civic participation	36	3.37 (1.15)	3.86 (0.96)	+0.49	172.0	< 0.001	0.66	0.55
Q2: Career interest	36	3.17 (1.25)	3.74 (1.05)	+0.57	171.0	< 0.001	0.89	0.66
Q3: Site interest	36	3.74 (1.02)	4.03 (0.85)	+0.29	65.0	0.017	0.35	0.35
Q4: Perceived difficulty	35	3.88 (1.05)	3.97 (0.95)	+0.09	209.0	0.311	0.06	0.08

Note: one-tailed tests; d is the standardised mean of the paired differences; $r = Z/\sqrt{N}$. Under Bonferroni correction (0.0125), Q1 and Q2 remain significant, Q3 does not.

Q1, Q2 and Q3 increased, the largest paired effect being observed for Q2. Q1 and Q2 remain significant under Bonferroni correction, whereas Q3 ($p = 0.017$) does not and is treated as a suggestive trend. Q4 showed no significant change, indicating that perceived tool difficulty remained stable while civic and professional interest rose. For Q2, 18 students improved, 18 remained stable and none declined. Since only 36 of approximately 50 participants returned usable paired responses, non-respondents may have differed systematically from respondents.

4.2 Post-only Survey Items

Table 2 presents the post-only items.

Table 2: Post-only survey results

Item	n	M (SD)	% Agree (4+5)
Q5: Identified park qualities/problems	39	3.49 (1.38)	56.4%
Q6: Want to use digital tools more	39	3.79 (1.52)	71.8%
Q7: Collaborated effectively	35	4.12 (1.05)	77.1%
Q8: Considered spatial arrangement	35	3.68 (1.13)	57.1%
Q9: Considered park users	35	3.74 (0.82)	62.9%
SoftQ1: 3D city looked realistic	35	4.12 (0.93)	74.3%
SoftQ2: Could materialise ideas	35	3.76 (1.16)	62.9%
SoftQ3: Game mode was exciting	33	4.47 (0.90)	90.9%

The game-mode exploration feature (SoftQ3) was the highest-rated item of the whole survey ($M = 4.47$, 90.9% agreement). Collaborative achievement (Q7) and 3D realism (SoftQ1) were also rated highly.

4.3 Conversational Shift From Operation to Design

The transcripts of the 12 groups yielded 21,612 words (2,666 unique). Table 3 presents the temporal evolution of utterance categories.

Table 3: Conversation analysis across three time phases

Phase	Total utterances	Cat. A (operational)	Cat. B (design)	Ratio B/A
Early (0-15 min)	1,370	752	618	0.82
Middle (15-30 min)	1,642	714	928	1.30
Late (30-45 min)	1,615	546	1,069	1.96

The association between time phase and utterance category was significant, $\chi^2(2, N = 4,627) = 134.1$, $p < 0.001$, although its strength is modest (Cramér's $V = 0.17$). Adjusted standardised residuals show operational utterances overrepresented in the early phase ($z = 10.2$) and design utterances in the late phase ($z = 9.7$), the middle phase matching expectation. The pattern is consistent with a progressive transition from tool-focused talk towards spatial and social reasoning. As noted above, tokens are nested within groups, so the probability value overstates the precision of the test; the monotonic rise of the B/A ratio is the more robust finding.

4.4 Qualitative Findings

4.4.1 Map annotations ($n=17$)

Students identified the park's central area as an activity hub and its periphery as a zone for rest and supervision. Annotations referenced diverse user groups including children, adults, elderly people and wheelchair users.

4.4.2 Open-ended responses ($n=34$)

Thematic coding identified five categories: engagement and enjoyment (about 10 responses, one student noting "I could give shape to my imagination"); interface difficulties (about 9 responses, camera control being the most cited challenge); feature requests (about 8 responses: a copy function, more asset variety, tablet compatibility); civic and spatial reflection (about 5 responses, including "I could rethink the city"); and peer learning (about 3 responses). Teachers observed that shy students participated actively and that the children's intentions for the site were clearly visualised.

5. Discussion

5.1 Effectiveness of Game-based Machizukuri for Civic Awareness

The pre/post increases on Q1 (civic participation) and Q2 (career interest in urban design), the latter with a large paired effect ($d = 0.89$), indicate more favourable civic orientations immediately after the session. Because the design is single-group and the measurements were separated by a few hours, these changes cannot be

attributed to the workshop itself: novelty, demand characteristics, the presence of teachers and facilitators, and the salience of the topic at the second measurement are all plausible contributors. The data support only the weaker claim that a single session is compatible with a short-term shift large enough to justify a controlled test. The direction of the finding is consistent with the PLATEAU UC22-011 results in Hokota City, although those rest on a post-only survey (MLIT, 2023).

A particularly instructive finding is the decoupling of perceived difficulty and attitudinal engagement: Q4 showed no significant change, yet Q1 to Q3 all increased. Motivational engagement therefore appears not to require the tool to become easy; the game context, supported by the 90.9% agreement that the game mode was exciting, may provide sufficient intrinsic motivation to sustain participation despite technical challenges. The interpretation remains tentative, since difficulty and motivation were each measured with a single item.

5.2 The Conversation Transition as a Process Indicator

The progressive shift from operational to design discourse (B/A ratio from 0.82 to 1.96) documents a change in the content of group talk during the session. It is consistent with a transition from tool mastery to spatial reasoning, although the categories index what students talked about rather than what they learnt, and no independent measure of learning was administered. The pattern aligns with the framework of Abdul Jabbar and Felicia (2015), in which well-designed game mechanics sustain learning processes rather than distracting from them. Time-series conversational evidence of this kind is rarely reported in the GBL literature on urban planning.

5.3 Comparison with Existing Approaches

Compared with Minecraft-based initiatives, the Godot-PLATEAU framework offers real geospatial data at actual scale rather than block-based approximation, a more detailed 3D representation (SoftQ1: 74.3%) and embodied first-person exploration (SoftQ3: 90.9%). It also introduces higher technical barriers: camera control was the most cited difficulty in the open-ended responses. This trade-off between realism and accessibility merits further investigation.

The P-PPS framework (de Sena et al, 2025) shares the present interest in converting gameplay into analysable spatial data, but operates within Minecraft's block grid. The coordinate-based logs used here allow finer-grained analysis, including continuous heatmapping and volume-weighted density.

5.4 Methodological Contributions

This study illustrates why non-parametric methods are appropriate for small samples of ordinal data: all four pre/post difference distributions violated normality, which would render parametric t-tests unreliable. It also illustrates the limits of such designs, since neither multiplicity nor clustering can be handled adequately at this sample size. The multi-modal design offers a template for GBL evaluation that avoids over-reliance on any single source, provided each source is weighted according to the strength of inference it can support.

5.5 Limitations

Several limitations should be acknowledged. First, the single-group pre/post design without a control group prevents any causal attribution; novelty, demand characteristics and social desirability may all contribute to the observed changes. Second, the attitudinal measures are single items written for this study, so their reliability and construct validity are unknown and they are more exposed to response-shift bias than validated scales. Third, four tests on 35 to 36 paired observations provide limited power, and only Q1 and Q2 survive correction for multiplicity. Fourth, students worked in 12 groups sharing one computer and one facilitator, so neither the survey responses nor the utterances are strictly independent; the analyses do not model this clustering and consequently understate uncertainty. Fifth, the dictionaries were fixed a priori and match about one fifth of the transcribed tokens, so design reasoning expressed in other vocabulary is not counted. Sixth, the 40% return rate for map annotations and the loss of roughly a quarter of participants from the paired survey introduce potential selection bias. Finally, the study involves a single school, site, age group and cultural context, and data preparation requires GIS and 3D modelling expertise that may limit adoption without dedicated facilitation.

6. Conclusion and Future Work

This paper presented a game-based machizukuri workshop integrating open-source technologies (Godot, Blender, PLATEAU) for youth participatory urban design and evaluated it through a mixed-methods approach. Within a single-group design, students reported higher willingness to participate in community activities and higher career interest in urban design, group discourse shifted from operational towards design-oriented content, the game-mode feature was the most positively rated item, and the zones annotated on paper maps

coincided visually with those in which assets were placed. These findings describe what was observed during and immediately after one workshop; they do not establish that the workshop caused the changes recorded.

The zero-cost, open-source nature of the pipeline, from national geospatial data to game-engine deployment, is a distinctive contribution to game-based participatory planning, and the study shows that multi-modal evaluation is feasible even for a single-session workshop with a small sample.

Future iterations will integrate standardised GBL instruments, spatial reasoning pre/post measures and non-player characters powered by large language models representing community stakeholders. The priority is a controlled comparison with more groups, so that clustering can be modelled explicitly. Comparative studies across age groups, urban contexts and cultural settings will help assess the transferability of the approach.

Ethics Declaration: The workshop was a curricular activity within the school's machizukuri and diversity education programme, approved in advance by the principal and class teachers, who reviewed the activity plan, the questionnaire items and the audio-recording procedure. Only group-level audio was recorded, and the recordings were used solely for transcription and automated tokenisation. Names and other identifying details spoken during the recordings were removed at transcription. Workshop questionnaires were linked by an anonymous code rather than by name and no personally identifiable information was retained in the analysis files. Response counts vary because some questionnaires were returned incomplete. The school is not named, the park is a public site, and no individual student is identifiable in the material reported here.

AI Declaration: An AI writing assistant was used during the preparation of this manuscript for language editing and for checking the internal consistency of the statistics reported in the tables. All AI-revised content was reviewed and approved by the authors. The research design, workshop implementation, data collection, statistical analysis, literature synthesis and interpretation of results were carried out by the authors.

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