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Using Minecraft to Develop Citizenship Competencies by Designing a Smart City

Fortaleciendo competencias ciudadanas a través del uso de
Minecraft para crear una ciudad inteligente

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Abstract

Serious-game environments have demonstrated efficacy in connecting theoretical concepts with practical application in university courses focused on social reform. This study assesses the influence of an immersive project in Minecraft: Education Edition on the enhancement of civic competencies and smart-city awareness among 28 undergraduate students participating in the “Citizenship and Smart Cities” course at Tecnológico de Monterrey (under TEC21 model), Campus Hidalgo, during the August–December 2024 semester. Through seven distinct phases, spanning community diagnosis to virtual urban redesign, students recognized tangible issues, devised contextually relevant remedies, and presented them via video walkthroughs of their Minecraft environments. Performance was evaluated using an institutional rubric, supplemented by a perception poll. Quantitative data indicate that 100% of students attained a proficient level in the “socially responsible solutions” (SEG0404); 82% achieved proficient and 3.5% outstanding levels in “critical reasoning” (SEG0503); and 75% attained proficient level in “strategic use of IT” (SEG0702). Survey data shown complete consensus that the unit promoted civic involvement, with 95% asserting that Minecraft enhanced their theoretical


comprehension. Qualitative remarks confirmed increased social awareness and motivation. These findings endorse the incorporation of immersive, game-based methodologies to develop twenty-first-century civic competences in higher education.

Keywords: serious games, minecraft, educational innovation, active learning, smart cities

Resumen

La aplicación de juegos serios ha mostrado su eficacia para acercar la teoría a la práctica en cursos universitarios orientados a la transformación social. El presente estudio evalúa el impacto de un proyecto inmersivo en Minecraft: Education Edition sobre el desarrollo de competencias ciudadanas y la comprensión de las ciudades inteligentes en 28 estudiantes de licenciatura inscritos en la unidad de formación “Ciudadanía y Ciudades Inteligentes” del Tecnológico de Monterrey (bajo el modelo TEC21), Campus Hidalgo, durante el semestre agosto–diciembre 2024. A lo largo de siete fases, desde el diagnóstico comunitario hasta el rediseño urbano virtual, los estudiantes identificaron problemas reales, diseñaron soluciones contextualizadas y las presentaron mediante recorridos en video de sus mundos de Minecraft. La evaluación, basada en una rúbrica institucional y una encuesta de percepción, mostró que el 100 % de los estudiantes obtuvo un nivel sólido en la sub-competencia “Compromiso ciudadano para la transformación social” (SEG0404), el 82 % un nivel sólido y el 3.5 % sobresaliente en “Pensamiento crítico” (SEG0503), y el 75 % un nivel sólido en “Tecnologías de vanguardia” (SEG0702). La encuesta reveló un acuerdo unánime en que la experiencia fomentó el compromiso ciudadano y el 95% de los alumnos encuestados afirmó que Minecraft profundizó su comprensión teórica. Los resultados obtenidos respaldan una mayor conciencia social, motivación y avalan la integración de enfoques lúdicos inmersivos para potenciar competencias ciudadanas en la educación superior.

Palabras clave: juegos serios, minecraft, innovación educativa, aprendizaje activo, ciudades inteligentes

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INTRODUCTION

The rapid urbanization of the planet, with over 68% of the population anticipated to reside in cities by 2050, necessitates graduates capable of analyzing intricate metropolitan issues, leveraging digital technology, and involving communities in the co-design of more habitable environments. International agendas, like United Nations Sustainable Development Goal 11 (Sustainable Cities and Communities) and UNESCO's Education for Sustainable Development for 2030 roadmap, delineate this necessity as both a technical and civic obligation (UNESCO, 2025). In Latin America and the Caribbean, where digital-transformation efforts expose stark equity gaps, a recent UNESCO report concludes that higher education must "equip students with hybrid civic-digital skill sets to steer inclusive smart-city transitions" (UNESCO, 2024).

Literature refers to these hybrid skill sets as civic and digital-citizenship competencies, which are a collection of values, knowledge, attitudes, and skills that enable individuals to engage responsibly in democratic life while traversing technology-rich environments. Frontier research on competency assessment in universities has identified information literacy, ethical technology use, and community engagement as the pillars that require the most curricular innovation (Mejias-Acosta et al., 2022). However, conventional lecture-centric methods frequently fail to cultivate the reflective, systems-thinking dispositions necessary for the development of cities in the twenty-first century.

Serious games have emerged as a compelling response to this pedagogical gap. A systematic review found that game-based learning environments consistently outperform conventional methods in fostering meta-skills such as problem-solving, collaboration and civic reasoning (Mitsea et al., 2025), while a Nature Humanities and Social Sciences Communications study highlights how even low-tech serious games can catalyze inquiry and deep learning in higher-education settings (Chen, 2025). By providing situated, consequence-laden contexts, serious games operationalize Kolb's experiential-learning cycle and invite learners to iterate between action and reflection, an approach particularly well-suited to wicked urban problems.

Minecraft: Education Edition holds a unique position among serious-game platforms. The open-world sandbox, customizable rule sets, and minimal entry requirements enable students to swiftly prototype spatial solutions while establishing shared understanding. Global efforts like Schools Reinventing Cities, in collaboration with C40, illustrate how Minecraft enables students to conceptualize climate-positive neighborhoods and convey these ideas to policymakers (Minecraft, 2025). Purpose-built environments such as Sustainability City enhance these capabilities by integrating real-time data and sustainability situations directly into the action. Despite this momentum, empirical research on Minecraft's influence on civic competencies is predominantly focused on primary and secondary school; robust data from Latin American higher education contexts remains limited.

Alongside the emergence of serious games, Challenge-Based Learning (CBL) has become prominent as a curricular framework that contextualizes disciplinary knowledge inside genuine, socially pertinent issues. Comparative studies indicate that CBL can produce substantial improvements in conceptual comprehension and collaborative skills in both engineering and general education courses (Robledo-Rella et al., 2025), while process-oriented research emphasizes the need of well-structured challenge phases to optimize group learning behaviors (Martin and Bombaerts, 2025). The TEC21 approach at Tecnológico de Monterrey university formalizes Challenge-Based Learning (CBL) through semester-long challenges developed in collaboration with community and industry partners. Incorporating Minecraft into this framework provides a synergistic approach: the platform gives an immersive environment for conceptualization and experimentation, while the CBL structure introduces authentic stakes and reflective support.

This study investigates the impact of an immersive, seven-phase Minecraft project integrated into a TEC21 general-education course "Citizenship and Smart Cities" on undergraduate students' (1) civic and digital citizenship competencies, (2) comprehension of smart-city principles, and (3) motivation to effect community change. This research provides essential empirical evidence from a Latin American higher education context by triangulating performance rubrics, perception surveys, and reflective artifacts, demonstrating a reproducible approach for utilizing serious games in challenge-based pedagogies. The findings intend to guide curriculum designers, educational technology researchers, and policymakers in developing scalable solutions to nurture the next generation of civic innovators.

METHODOLOGY

This investigation was structured by a convergent mixed-methods design, which combined qualitative perception data with quantitative performance metrics to construct a comprehensive understanding of the learning impact.

Setting and Participants

The project occurred at Tecnológico de Monterrey, Campus Hidalgo, during the August–December 2024 semester (course code EC1019). Twenty-eight undergraduates (16 male, 12 females; mean age = 20.3) from engineering, business, and humanities disciplines participated in two course sections.

Pedagogical Design

TEC21's CBL ethos was translated into a Minecraft-mediated experience through seven sequential phases: (1) theoretical grounding in urbanism and civic participation; (2) field-based community diagnosis using empathic "walk-in-their-shoes" simulations; (3) exploration of emerging smart-city technologies, including a guided visit to the Hidalgo state's C5i control center; (4) technical onboarding to Minecraft: Education Edition; (5) community-specific data collection through interviews and observations; (6) collaborative design and digital construction of an urban-redevelopment proposal; and (7) public exhibition and defense of the proposal via video walkthroughs and pitch presentations.

Assessment Instruments

Performance Evaluation Criteria: Three institutional sub-competencies were identified: SEG0404 (socially responsible solutions), SEG0503 (critical thinking), and SEG0702 (strategic IT use). The evidence comprised the Minecraft universe, a narrated video tour, and a detailed presentation show.

Perception Assessment: A four-item Likert scale questionnaire assessed students' self-reported improvements in civic participation, critical thinking, technological proficiency, and personal development.

Reflective Journals and Focus Group Debriefing: These qualitative artifacts offered insights into emotional engagement, team dynamics, and perceived authenticity of the task.

Data Analysis

Descriptive statistics were employed to summarize rubric scores, while open-ended survey responses and journals were thematically categorized by iterative constant-comparison to triangulate quantitative trends.

Ethical Considerations

Informed consent was obtained; data were anonymized, and the study adhered to institutional research-ethics protocols.

THEORETICAL FRAMEWORK

Civic and Digital-Citizenship Competencies

The Reference Framework of Competences for Democratic Culture defines civic competence as a composite of values, attitudes, abilities, and knowledge that empower individuals to "function as active citizens" and "coexist harmoniously" (COE, 2025). In digital environments, these competencies encompass responsible, critical, and creative interaction with information technologies. Research on digital citizenship education highlights the necessity of combining ethical technology usage with civic involvement to equip learners for smart-city environments.

Serious Games and Experiential Learning

Serious games are game environments that are intended for purposes other than entertainment, such as learning, professional development, or social transformation. By providing a concrete virtual experience, inviting reflection, and facilitating repeated experimentation, they exemplify Kolb's (1984) experiential-learning cycle (Pacheco-Velázquez et al., 2023). Szot's (2024) framework for selecting games for civic engagement further emphasizes the potential of video games to democratize urban-planning processes by providing a "space to deliberate with for a variety of stakeholders."

Minecraft for Smart-City and Civic Education

Minecraft's block-based sandbox facilitates the swift prototyping of intricate spatial concepts, promoting cooperation, negotiation, and systems thinking. Latin American case studies demonstrate that Minecraft enables learners to visualize urban disparities, evaluate design interventions, and convey remedies to local authorities. Its significance is enhanced when combined with empirical data, such as GIS layers or community surveys, facilitating reciprocal learning between the physical and virtual domains.

Challenge-Based Learning in the TEC21 Model

TEC21 model organizes learning around genuine challenges sourced from industry or community collaborators. CBL has proved an enhancement in student agency, self-efficacy, and multidisciplinary collaboration within engineering and social science courses. Integrating Minecraft into a TEC21 assignment leverages its adaptable, learner-directed environment while preserving a direct connection to community influence.

RESULTS

At the conclusion of the academic term during which Minecraft: Education Edition was utilized as a technical resource to foster academic innovation; a thorough evaluation was conducted to assess its impact and get insights into the students' perceptions. The primary objective of this effort was to cultivate transversal abilities, including civic involvement, critical thinking, dialogic communication, and the application of advanced technology. A diagnostic survey was conducted to assess the students' prior understanding of utilizing Minecraft in a non-recreational educational context. The findings revealed that 33% of participants possessed prior experience with the tool, whilst 67% lacked familiarity in this domain.

A rubric that concentrated on the subsequent sub competencies was implemented in order to conduct an impartial assessment:

Socially responsible solutions (SEG0404): Develops strategies that enhance democracy and the common good by constructing committed, sustainable, and supportive solutions to social issues and needs.

Critical thinking (SEG0503): Assesses the validity of their own and others' reasoning, recognizing and contradictions that enable them to form a well-informed judgment in situations or issues.

Strategic IT Use (SEG0702): Conducts an impartial assessment of a variety of information technologies, identifying and executing pertinent alternatives to revolutionize professional practice.

The evaluation was conducted using the university's official technological platform, with two deliverables serving as the primary evidence: 1. A video that utilized Minecraft to digitally reconstruct the intervened colony, providing a virtual tour. 2. A PowerPoint presentation that incorporated all of the information collected throughout the semester, including a community diagnostic, theoretical analysis, and urban design proposal.

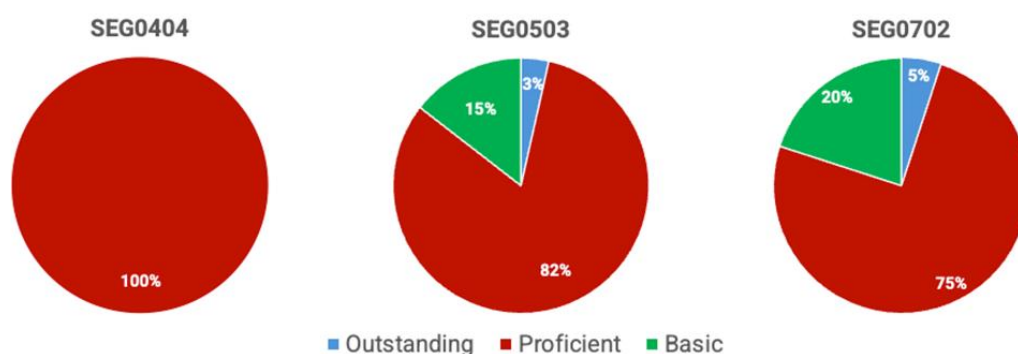
Quantitative Learning Gains

All 28 students attained a proficient level in creating a “Socially responsible solutions” sub-competence (SEG0404), demonstrating their capacity to design socially responsible and context-aware solutions. In “Critical thinking” sub-competence (SEG0503), 82% of participants achieved a proficient score, 3.5% attained an outstanding score, while 14.5% were at a basic level. For “strategic IT use” sub-competence (SEG0702) achieved a 75% proficient level, indicating effective selection and integration of information technologies (Figure 1).

Graphic 1

Levels obtained by the students for each of the sub-competencies evaluated

Source: Own elaboration with data collected by the authors.



Perception of Learning Experience

The survey results reflected the performance data: 100% of respondents concurred that the project enhanced civic, critical-thinking, and technological competencies; 95% believed that Minecraft enriched conceptual understanding; and 100% indicated they felt like “better citizens” after completing the course.

Qualitative Insights

Six recurring themes emerged from journals and focus-group transcripts:

Empathy and Perspective-Taking: Students reported heightened awareness of accessibility barriers after simulating disabilities during the neighborhood walk.

Systems Thinking: The block-by-block construction process compelled teams to consider interdependencies (e.g., transport, green spaces, safety).

Collaborative Negotiation: Building in real time required constant communication and compromise, mirroring participatory urban-planning processes.

Motivation through Play: The intrinsic enjoyment of Minecraft sustained engagement in research and iteration phases.

Transfer to Real-World Contexts: Several teams arranged meetings with local municipal staff, presenting their virtual models as informal policy suggestions.

Personal Growth: Students described a shift from “passive observers” to “active changemakers.”

Representative student comments include: “My vision changed from the first moment, I now recognize my community’s needs” and “I was pushed out of my comfort zone, but in the best possible way.”

DISCUSSION

The objective of this study was to determine whether an immersive, seven-phase Minecraft: Education Edition project that is integrated into TEC21’s challenge-based learning (CBL) framework could enhance the development of civic-competency in undergraduates and enhance their understanding of smart-city concepts. The mixed-methods evidence—unanimous self-reported civic growth, robust gains in critical reasoning and strategic IT use, and 100% solid performance in socially-responsible solutions—confirms that serious-game experiences can catalyze holistic competency gains when they are tightly coupled with authentic community challenges. In the following section, we contextualize these findings within the realm of contemporary scholarship, identify theoretical and practical contributions, and propose potential future research orientations.

Positioning the Findings within the Serious-Games Literature

Recent meta-analyses and systematic reviews indicate the increasing significance of serious games in higher education during the past two years. Brandl and Schrader’s (2024) systematic analysis of 28 higher education interventions suggests that game-based designs are most effective when matched with institutional reform initiatives like “Education 4.0.” Our findings reflect this trend: the intervention’s congruence with TEC21’s CBL philosophy is pivotal to the elevated performance rates, indicating that the selection of platform (Minecraft) and pedagogical framework (CBL) function synergistically rather than autonomously.

The diverse disciplinary scope of our cohort aligns with García-Álvarez and Acevedo-Borrega’s (2025) evaluation of 67 studies, which underscores Minecraft’s applicability in STEM, design, and social sciences while indicating a lack of Latin American university examples. The study provides actual data from a Mexican campus, addressing a geographical need and enhancing the external validity of previous school-level research.

Lastly, the robust rubric improvements in strategic IT use (SEG0702) are consistent with the validation of a digital-competencies assessment by Mejías-Acosta et al. (2024), which identifies “digital empathy” and “creation of digital content” as essential graduate attributes. The scale is provided construct-level support in a live CBL context through the narrated walkthroughs and public exhibitions of students, which illustrate both dimensions in practice.

Toward Participatory Smart-City Pedagogies

In addition to overall competency improvements, the findings indicate that Minecraft serves as a participatory planning simulator, a conclusion supported by two innovative research. De Sena et al. (2025) demonstrate how a Playful Participatory Planning System may transform in-game constructions into GIS layers for municipal analysis. Although our experiment did not achieve bi-directional data transmission, many student teams utilized their worlds as discussion points in meetings with local officials, suggesting analogous translational opportunities. In a complementary manner, the hybrid analog–Minecraft game developed by Egusa, Kimura, and Tsuji (2025) for urban greening highlights the significance of multimodal, collaborative design cycles in understanding sustainability trade-offs. This study applies similar reasoning to a higher education context, illustrating that undergraduate teams can navigate intricate constraints, accessibility, safety, green-space ratios, within a controlled environment and subsequently express those agreements in policy-focused terminology.

Limitations and Quality-Assurance Considerations

The generalizability of these findings is limited by a number of constraints. Initially, causal claims are not admissible due to the absence of a control group; therefore, quasi-experimental replication across TEC21 campuses is necessary. Subsequently, performance was evaluated using a single institutional rubric. The measurement robustness would be improved by incorporating externally validated instruments, such as the 22-item digital-competence scale of Mejías-Acosta et al. (2024). Third, self-selection bias may have inflated perception scores; longitudinal follow-ups could determine whether competency gains endure after novelty subsides.

CONCLUSION

This study reveals that the integration of Minecraft: Education Edition into a TEC21 challenge-based learning environment can significantly enhance the civic and digital-citizenship competencies of undergraduate students, while also enhancing their comprehension of smart-city principles. The project transformed abstract course outcomes into concrete, socially responsive artifacts by guiding learners through a seven-phase sequence that includes community diagnosis, empathic field immersion, iterative virtual prototyping, and public exhibition. Additionally, students reported a stronger inclination to engage with local decision-makers, a keener sense of agency, and heightened empathy, in addition to fulfilling the formal performance indicators of socially responsible solution design, critical reasoning, and strategic technology use. The whimsical, consequence-laden environment of Minecraft can serve as a catalyst for reflective citizenship, particularly when it is framed by authentic community challenges and supported by structured reflection, as these qualitative shifts suggest.

The collaboration between platform and pedagogy was crucial. The open-world capabilities of Minecraft enabled teams to visualize and evaluate interdependent urban systems in real time, while the TEC21 model provided the real-world implications that maintained motivation and accountability. This alignment emphasizes a fundamental principle for curriculum design: serious games provide optimal educational benefits when integrated within institutional structures that prioritize interdisciplinary collaboration, societal impact, and iterative learning processes. This integration alleviates prevalent faculty apprehensions regarding rigor and evaluation, as the platform's outputs align seamlessly with competency-based rubrics and may be evaluated with equivalent transparency to conventional deliverables.

In addition to the immediate educational benefits, the project provides a reproducible framework for expanding participatory smart-city teaching across other campuses and disciplines. The resource footprint, essential gear, a site license for Minecraft: Education Edition, and faculty development workshops, remains modest compared to the motivational and intellectual benefits. Furthermore, the

students' initiative in presenting their virtual recommendations to municipal personnel suggests a promising opportunity for university-community collaborations: virtual environments can serve as low-risk "policy sandboxes" for the exploration of innovative concepts prior to actual execution. As cities globally contend with swift urbanization and increasing equity disparities, such platforms may democratize preliminary planning, allowing diverse stakeholders, including students, who are frequently marginalized in traditional urban design processes to contribute their perspectives.

It is true that the study's scope was restricted: it was conducted on a single campus, lacked a control group, and was partially reliant on self-reported data. As a result, future research should implement quasi-experimental or multi-institutional designs, incorporate affective-analytics modules to capture in-game engagement patterns, and monitor longitudinal outcomes to ascertain whether the observed civic dispositions persist beyond the course. However, the convergent evidence presented herein establishes immersive, game-based learning as a viable, scalable strategy for the development of digitally fluent, socially responsible graduates who are capable of co-designing wiser, more inclusive cities, rather than a novelty. This serves to advance the emerging consensus that the grand challenges of twenty-first-century urban life necessitate educational experiences that are as interconnected, participatory, and adaptive as the smart cities our students aspire to construct.

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