

MAPPING REGENERATION: SYSTEMIC THINKING AND DIVERSITY IN DESIGN EDUCATION THROUGH GIGAMAPS IN MEXICO'S SIERRA GORDA

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ABSTRACT

This paper examines how Gigamapping can support systemic and regenerative thinking in design education through a place-based pedagogical experience developed in the School of Architecture and Design. The study was conducted within a sixth-semester Regenerative Design concentration in collaboration with rural communities in Mexico's Sierra Gorda. Students engaged in ethnographic observation, participatory process, and iterative analogue and digital Gigamapping to explore socio-ecological relationships across multiple scales.

The pedagogical framework combined principles of regenerative design, System-Oriented Design (SOD), and systemic visualisation methods to support students in moving beyond isolated problem-solving toward interconnected socio-ecological and cultural understanding of the place. In this study, Gigamapping is understood as a systemic visualisation practice that enables participants to externalise, connect, and iteratively reframe complex relationships among human and non-human actors.

Data were collected from two student cohorts through pre–post surveys on regenerative awareness and a post-course Systemic–Regenerative Learning Scale assessing five dimensions: system boundary expansion, relational complexity, epistemic diversity recognition, reflexivity, and leverage point identification. Survey findings were triangulated with comparative analysis of analogue and digital Gigamaps.

Results show that Gigamapping fostered more relational and systemic ways of thinking. It also served as an integrative tool for systemic reflection and interpretation in place-based regenerative learning. In this article, “regeneration mapping” describes the use of Gigamapping to visualise regenerative socio-ecological and cultural dynamics.

Keywords: Professional education, educational innovation, systemic design, regenerative design education, diversity, Gigamaps, co-creation, ethnography, design pedagogy

1 INTRODUCTION

Humanity is currently facing an escalating socio-ecological crisis in which human activities are destabilising the environmental systems that sustain life. Recent assessments indicate that six of the nine planetary boundaries have already been transgressed, revealing the limitations of development models centred on extraction and short-term growth [2]. Within this context, regenerative perspectives have emerged as alternatives that seek not only to reduce harm, but also to restore and strengthen socio-ecological systems over time [2][3][4].

Regenerative design proposes that human systems should co-evolve with natural systems through long-term relational approaches. Beyond sustainability understood as impact reduction, regenerative design seeks to restore and strengthen ecological, cultural, and territorial relationships over time [2][3][4]. Recent research highlights the importance of systems thinking, transdisciplinary collaboration, and situated learning in addressing complex socio-ecological transitions [1][3][9][10].

Systemic design offers methodological approaches for engaging such complexity by integrating systems thinking with design practice [5]. Within this field, System-Oriented Design (SOD) emphasises relational analysis, systemic and relational visualisation, and iterative reframing processes to support intervention within complex socio-ecological systems [6].

A central method within SOD is Gigamapping. In this study, Gigamapping is understood as a systemic visualisation practice used to externalise and explore relationships among actors, infrastructures,

ecological processes, and institutional dynamics [6][7]. Unlike conventional mapping approaches focused on static representation, Gigamapping enables the visualisation of multi-scalar interdependencies, feedback loops, and non-linear relationships while integrating diverse forms of knowledge within a shared visual environment.

This relational perspective becomes particularly relevant in place-based learning contexts characterised by ecological, cultural, and epistemic diversity. Complexity emerges not only from the number of interacting variables, but also from the coexistence of multiple ways of understanding territory and sustainability [1]. Design education therefore plays a critical role in preparing future practitioners to engage regenerative transitions through more reflexive and systemic forms of learning.

This paper investigates how Gigamapping can support systemic and regenerative learning within a place-based educational context developed in collaboration with rural communities in Mexico's Sierra Gorda. Through ethnographic fieldwork, participatory engagement, and iterative analogue and digital Gigamapping, students explored socio-ecological relationships across different territorial scales.

More specifically, the study examines the extent to which Gigamapping contributed to the development of regenerative learning skills, including expanding the boundaries of the system, recognising relational complexity, integrating epistemic diversity, developing reflective awareness, and identifying points of influence for regenerative intervention.

2 METHODOLOGIES

2.1 Research Design

This study adopted a practice-based pedagogical research approach combining educational intervention with reflective evaluation of learning outcomes. The objective was to examine how Gigamapping, integrated within a place-based regenerative design course, supported students in developing systemic and regenerative ways of understanding territory. Figure 1 shows the Methodological framework used for this study.

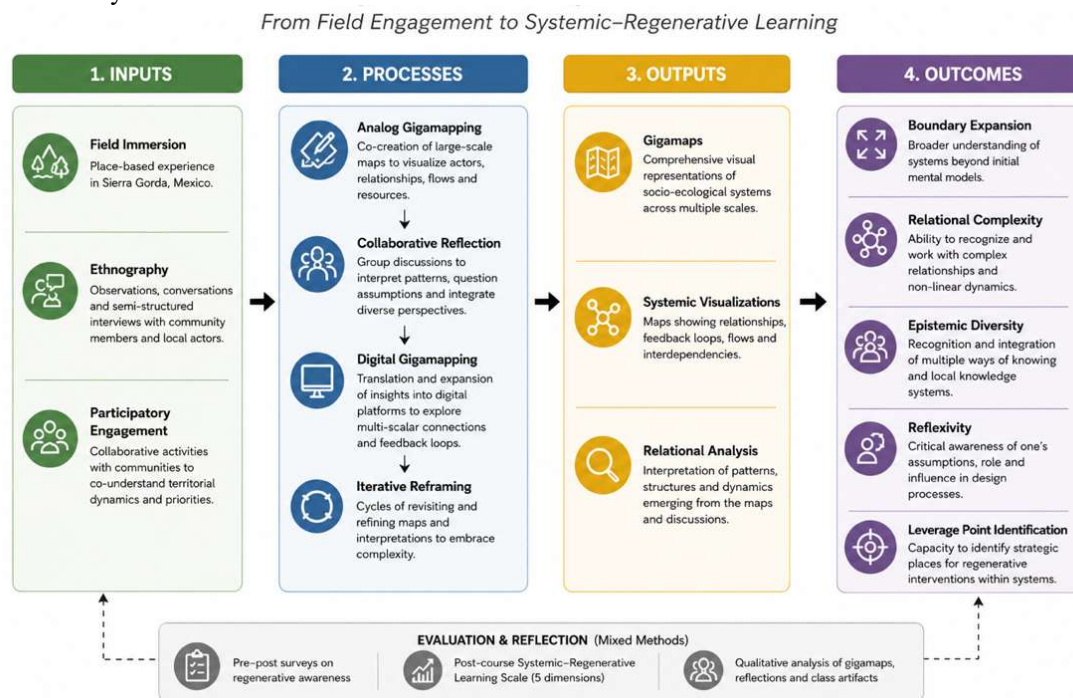


Figure 1. Methodological Framework

The study was conducted across two iterations of a sixth-semester Regenerative Design Concentration at the School of Architecture and Design, of Tecnológico de Monterrey, campus Querétaro, for 5 months. Both cohorts (2024: 9 students; 2025: 14 students) collaborated with 2 rural communities in Mexico's Sierra Gorda (Ejido La Barranca and San Gaspar) through field immersion activities involving ethnographic observation, participatory engagement, and systemic visualisation. The pedagogical framework integrated three complementary dimensions (Figure 2):

1. Regenerative Design Principles [3][4]
2. System-Oriented Design approaches to complexity [6]
3. Gigamapping as a systemic visualisation and reflexive learning practice [5][6]

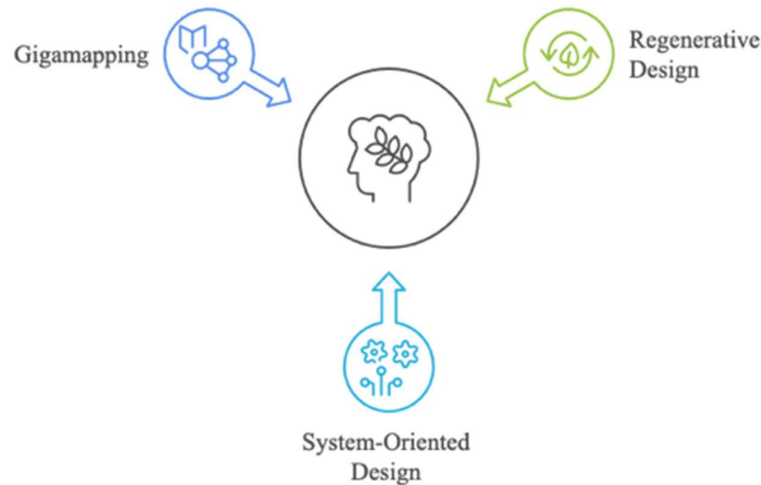


Figure 2. Pedagogical framework integrating Regenerative Design, System-Oriented Design, and Gigamapping within a place-based learning process

2.2 Pedagogical Process and Gigamapping

The pedagogical process was structured as practice-based pedagogical action research in which students progressively expanded their understanding of territory through observation, participation, and systemic visualisation. Rather than treating mapping as a final representational output, the course positioned Gigamapping as an iterative process for organising complexity, questioning assumptions, and identifying relationships across scales, as shown in Table 1.

Table 1. Comparison between Mapping and Gigamapping

TRADITIONAL MAPPING	GIGAMAPPING
Static representation	Dynamic system
Single scale	Multi-scale
Human Actors	Human + Non-human Actors
Linear	Non-linear / loops

Fieldwork was conducted in collaboration with rural communities in Mexico's Sierra Gorda. Students engaged in ethnographic observation, informal conversations, participatory activities, and territorial documentation to identify ecological, social, institutional, and cultural dynamics embedded in the local context, as regenerative understanding of place.

Gigamapping was implemented in two sequential phases (Figure 3). During field immersion, students collaboratively developed large-format analogue maps to externalise observations, actors, and emerging relationships. These maps were later translated into digital Gigamaps using the Kumu platform, enabling greater relational density, feedback visualisation, and multi-scalar analysis across micro, meso, macro, and bio-regional levels [7]. The transition from analogue to digital mapping functioned as a reflexive reframing process through which students reconsidered system boundaries and identified leverage points for regenerative intervention.

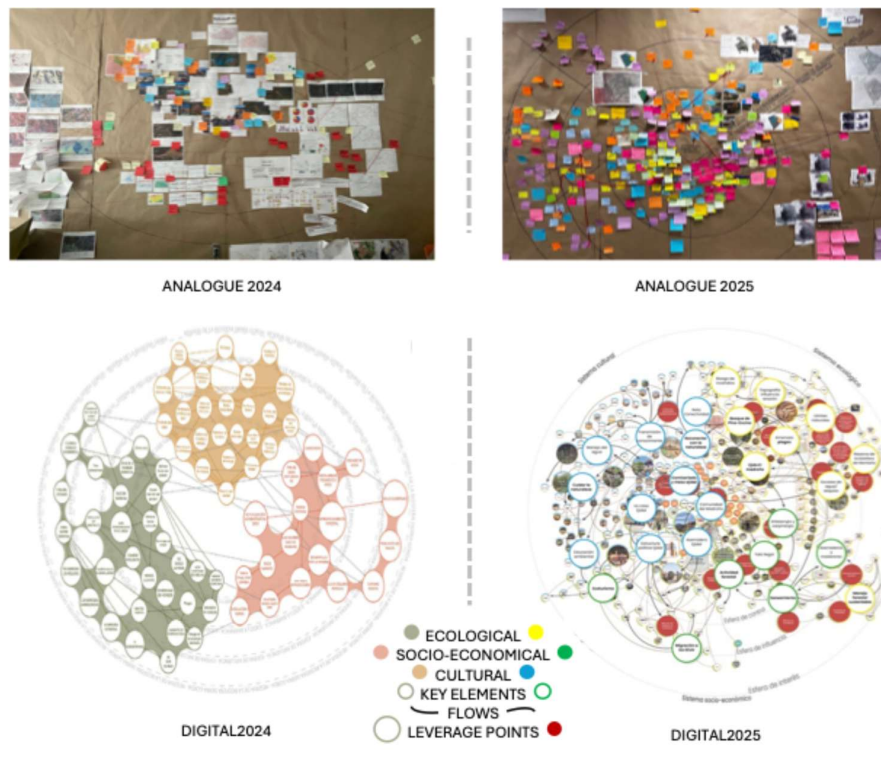


Figure 3. Evolution from analogue to digital Gigamaps across the 2024 and 2025 cohorts

2.3 Instruments and Data Analysis

Two complementary instruments were used to assess learning outcomes. First, students completed pre-post surveys measuring perceived knowledge of regenerative design principles and the perceived importance of integrating regenerative design into professional formation. Second, a post-course Systemic-Regenerative Learning Scale assessed five dimensions: system boundary expansion, relational complexity, epistemic diversity recognition, reflexivity, and leverage point identification. Survey data were analysed descriptively due to the small cohort sizes. Findings were triangulated with comparative analysis of analogue and digital Gigamaps to identify recurring learning patterns across both course iterations.

The study is exploratory in nature and relies primarily on self-reported data. However, consistency across two consecutive cohorts and convergence between survey responses and visual artifacts provide preliminary evidence supporting the pedagogical value of Gigamapping within systemic-regenerative learning contexts.

3 RESULTS AND LEARNING PATTERNS

Findings integrate three sources of evidence across two consecutive iterations of the Regenerative Design concentration (FJ2024 and FJ2025): (1) evolution of analogue and digital Gigamaps, (2) pre-post responses to Questions 18 and 19 on regenerative awareness, and (3) a post-course Systemic Learning Scale assessing perceived development of systemic thinking capacities.

Across both cohorts, students progressively shifted from localised and linear interpretations of territory toward broader systemic understandings. Initial analogue maps focused primarily on visible local challenges and immediate actors, whereas digital Gigamaps incorporated ecological systems, institutional dynamics, feedback relationships, and non-human actors, revealing greater relational complexity and multi-scalar awareness.

The transition from analogue to digital mapping also supported reflexive reframing processes. Students reconsidered initial assumptions, reorganised categories, and increasingly integrated local knowledge, ecological processes, and community perspectives into their interpretations of territory. Survey responses reinforced these patterns, indicating stronger awareness of interdependence, epistemic diversity, and reflexive thinking following the Gigamapping process (Figure 4).

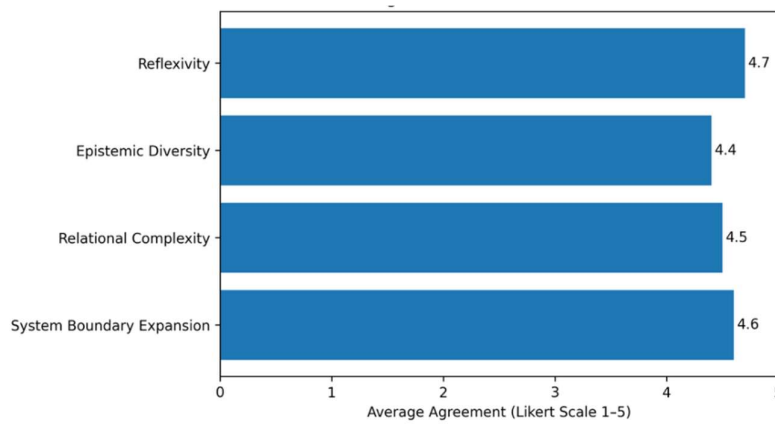


Figure 4. Comparative synthesis of students' perceived development across four systemic-regenerative learning dimensions following the Gigamapping process

Survey data additionally indicated increased perceived knowledge of regenerative design principles across both cohorts, while the perceived importance of regenerative design remained consistently high before and after the course (Figure 5). These findings suggest that the pedagogical process contributed primarily to expanding students' systemic-regenerative understanding rather than altering their initial valuation of sustainability-related issues.

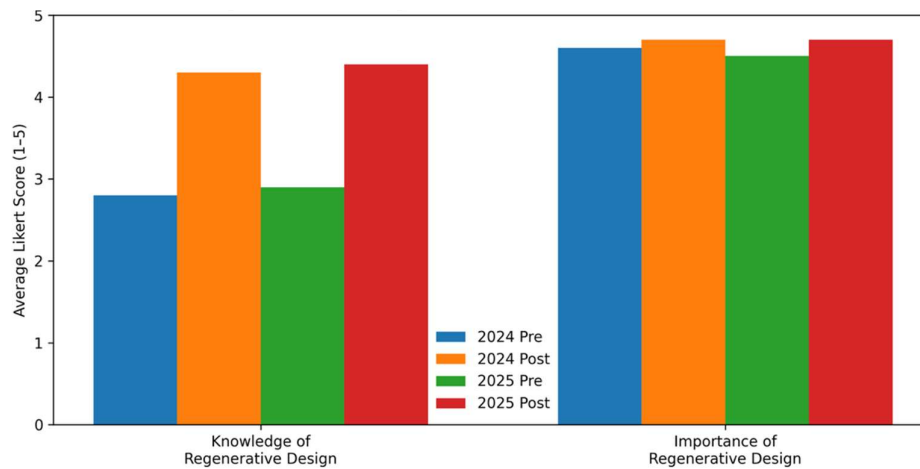


Figure 5. Pre-Post comparison of students' perceived knowledge and perceived importance of regenerative design across the 2024 and 2025 cohorts

Overall, findings across surveys and visual mapping artifacts suggest that Gigamapping functioned as a reflexive and integrative mechanism supporting systemic interpretation, relational synthesis, and regenerative awareness within place-based design education contexts.

4 DISCUSSION AND CONCLUSIONS

The findings suggest that systemic and regenerative learning emerged through the interaction of multiple pedagogical components, including field immersion, participatory engagement, ethnographic observation, and iterative reflection. Therefore, the study does not claim that Gigamapping alone produced the observed learning outcomes. Rather, the mapping process functioned within a broader place-based pedagogical ecology that supported students in interpreting territorial complexity through relational and systemic perspectives.

However, evidence across both cohorts indicates that Gigamapping functioned as a central integrative mechanism within the broader pedagogical process. The maps enabled students to externalise observations, visualise relationships across scales, compare perspectives, and iteratively reframe their understanding of territory. The progression from analogue to digital Gigamaps revealed increasing

relational density, incorporation of non-human actors, and greater recognition of ecological, institutional, and cultural interdependencies.

The study also highlights the importance of epistemic diversity within systemic design education. Students progressively integrated local knowledge, ecological processes, and community perspectives into their interpretations of territory, reinforcing the value of place-based learning in regenerative education contexts.

Although developed within a specific territorial context, the pedagogical approach presented in this study can be applied to other contexts through immersion in place, collaborative visualisation, iterative reframing, multiscale analysis, and epistemic plurality, generating more reflective and relational forms of learning that can help students address socio-ecological complexity.

Even though exploratory and limited in scale, self-reporting bias, lack of a control group, and difficulty in isolating the effects of Gigamapping, the recurrence of similar patterns across two consecutive cohorts suggests that Gigamapping may support the development of systemic literacy and regenerative agency in future designers.

By integrating regenerative design, System-Oriented Design, and place-based learning through systemic visualisation practices, this paper contributes a transferable pedagogical model for systemic-regenerative learning in higher education design contexts.

5 FUTURE WORK

Future research could expand this study across institutions, disciplinary contexts, and territorial settings to evaluate the transferability of the pedagogical model, further examine the specific contribution of Gigamapping within place-based learning approaches, and develop validated instruments for assessing reflexivity and systemic reasoning in design education.

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