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Error Harvest: A Method for System Design in Non-Ideal Conditions

Marko-Luka Zubčić
Institute of Philosophy in Zagreb, Croatia
e-mail: mlzubcic@ifzg.hr
ORCID: 0000-0002-7637-2455

Ida Križaj Leko
University of Rijeka, Urban Studies, Croatia
e-mail: ida.krizajleko@uniri.hr
ORCID: 0009-0000-5378-314X

ABSTRACT In this paper, we present "error harvest", a new method for educating and training designers of complex sociotechnical and spatial systems (for example, urban units) under non-ideal conditions. Error harvest confronts the designer with the explication of inherent flaws and predictable (although perhaps rare or unlikely) shocks in the found system, and represents an exercise in reinterpreting (by means of design solutions) these flaws and shocks as productive mechanisms of the system (with productivity defined within the exercise as the desired goals that the mechanisms should achieve). In the article, we present and elaborate the method within and in relation to the fields of spatial practices, system design, broken world design, and non-ideal institutional epistemology. In conclusion, we present two different examples of the use of the method.

Key words: system design, non-ideal theory, broken world, education, institutional epistemology.

1. Introduction

The aim of this paper is to present a new, original method for educating and training designers[1] of complex sociotechnical systems (for example, urban units) under non-ideal conditions, called *error harvest*. Error harvest confronts the designers with the explication of inherent flaws and predictable (although perhaps rare or unlikely) shocks in the system in its present condition and represents an exercise in reinterpreting these flaws and shocks as productive mechanisms of the system (with productivity defined within the exercise by the desired goals that the mechanisms should achieve). Error harvest is the exact opposite of “burying one’s head in the sand” when confronted with high complexity systems and epistemic constraints faced by designers; Error harvest is a tool for educating and training a new generation of designers and preparing them for a substantial and explicit confrontation with non-ideal conditions and inevitable limitations of design, but also for *cunning* in design, through training focused on reconceptualizing flaws and shocks as *resources* that can be used to achieve a more reliable (adaptable, resilient and productive) functioning of complex sociotechnical systems. Error harvest can be used to develop specific solutions; however, its key educational purpose is developing sensibility for analyses and interventions in truly open, complex, and opaque systems, and cultivating imaginative courage, epistemic humility, and intellectual honesty in design based on calibrated views (Cook, 1998) of flaws, hazards, and shocks inevitable in a non-ideal, broken world.

Error harvest was developed in 2018 by the authors of this paper. That same year, it was presented for the first time, under the working title *Disequilibrium Utility*, to architecture students gathered for the purpose of organizing the European Architecture Student Assembly in Rijeka with the aim of addressing and analyzing the topic of disturbances or extreme conditions as the initial context for planning and design. The most relevant contemporary application of the method is its use in the Urban Studies program at the University of Rijeka.

This paper is structured as follows: Section 2 presents the method; Section 3 explores the position of the method in the field of spatial practices and system design and elaborates its theoretical foundations from the standpoint of three key schools of thought; Section 4 provides an example of the use of the method in the teaching process in Urban Studies at the University of Rijeka.

[1] In this paper, we use the term *designer* for all types of design. In the local context, depending on the field, we sometimes also use *shaping* and *planning*.

2. Structure of the Method

In the broadest sense, the error harvest method consists of three simple steps.

The first step is to create a list of "errors" in the observed system, be it predictable, unwanted consequences of design decisions, or inevitable problematic aspects of specific material or social processes inherent to the real world or the type of system observed. Also, errors can be linked to the system itself; however, they can also be found outside the system and still have a predictable impact on or interactions with it. We call the errors "tools" to emphasize their transformation, by using the method, into productive factors in the system. In our application cases hitherto, such tools often included a) extreme transiency of space (too many or too few people, temporary use of space at irregular intervals, neglect), and b) *subnature* (Gissen, 2009), i.e. undesirable by-products of natural processes, urbanization and industrialization, like smog, industrial smoke, exhaust, dust, debris, ruins, and weeds. Furthermore, all observed systems involve inherent and locally specific errors to be transformed into tools – in the case of the Rijeka Campus, in addition to transiency and subnatural elements, extreme conditions of powerful gusts of bora through fast wind corridors between buildings and open deforested areas are an obvious example of an error ready to be transformed into a tool.

The second step is to curate the errors to be transformed into tools and to specify what precedes and what follows from the transformation of the error that the designer will use in the training.

The third step is to select a systemic goal for the designer to achieve using the chosen pair of tools. The goals can vary, and a list of goals can be prepared in advance so that the group undergoing training can divide different tools and goals among its members when working on the same system. In an example of the use of our method so far, the goal was to provide a system for basic needs – food, water, energy, shelter, and similar. In another example, the goals were linked to system toughness – surplus, additional communication channels, and facilitating randomness (deprograming, deplanning).

With these three key steps, depending on the requirements of the training and the specified learning outcomes, it is also possible to define other characteristics of the system, like different scales, time intervals, and similar.

While we consider simplicity to be one of its strengths, in the following section, we give a more detailed elaboration of the position and theoretical foundations of the method in the context of the relevant disciplines in order to clarify its educational purposes.

3. Theoretical Foundations of the Method in the Context of Relevant Disciplines

3.1. Situating the Method in the Context of System Design

A detailed history of system design theory would require, at the very least, an entire book. It's a "fuzzy" discipline, closest to current interdisciplinary, transdisciplinary, and multidisciplinary research programs dedicated to a subject or problem associated with the term "studies". In the broadest sense, systems are webs of interrelated components where, in addition to the behavior of the components through their relationships, the entire web also produces a certain behavior. Furthermore, systems exhibit various degrees of complexity – different levels of predictability in component relationships; countability and legibility of components and relationships, and emergent properties that are not evident in countable and legible components and relationships or cannot be predicted based on the properties of the components and their relationships.

In this paper, due to its subject and space constraints, we will not present the genealogy of the research program or a detailed overview of system design theory, but focus instead on a very rough (and by no means exhaustive) outline of some key insights from system design theory developed, specifically, due to the influence of institutional economics and epistemology, which can help understand the role of error harvest as an addition to the educational methodological repertoire in the field of system design, regardless of the type of the system, be it in the area of public policies, strategic and institutional design, urbanism or regional development.

First, it is crucial to distinguish systems based on whether they tend toward stability or adaptability. Some systems require a relatively stable degree of finality – as is often the case with public normative systems, e.g., traffic signage systems, which must be final and unambiguous to perform their function. However, many systems, especially those most often dealt with by experts in public policies, spatial and strategic planning, architecture, regional development and institutional design, require a productive tension between achieving stability of the normative structure to facilitate agent coordination and capacity for continuous learning, in the sense of 1) adaptation to new unpredictable defects, conditions and crises, 2) systemic adaptation to new emergent coordination patterns, and 3) capacity for continuous upgrading of provisional institutional solutions.

Therefore, a significant number of systems, particularly sociotechnical systems, require a continuous openness to learning, adaptation, and innovation; if they are closed off and production of surpluses is prevented, they become stabilized in a suboptimal state, often resulting in epistemic collapse (performance that fails to meet any of the target values). However, such closing off is a common practice – it could be argued that we are living in an era of multiple crises precisely because we over-stabilized our energy and materials system through oil technologies, and because we over-stabilized our governance systems by delegating governance to the richest members of society.

The key development in system design is the discovery, chiefly derived from the work epistemic institutionalists (Hayek, 1945, 1978; Ostrom, 2005) and, arguably, pragmatists (see Brandom, 1994 for error-recognition in particular), that (except for subsets of systems [like the traffic signage system] which require stabilization because they address fundamentally "tame" problems [Rittel and Webber, 1973]) designers need to meet two requirements in system design: a) facilitate coordination by means of an explicit system of rules, and b) facilitate efficient systematic detection and correction of errors (Wimsatt, 2007; Zubčić, 2019). These two requirements, or values, are complementary, not conflicting – in complex systems, explicit rules are used to facilitate and protect the capacities for coordinating agents, subsystems, and the system as a whole, but also the capacities for continuously upgrading coordination patterns with new solutions. In other words, the capacity for "metabolism of error" (Wimsatt, 2007) *requires institutional protection*. Over-stabilized systems are frail precisely because they lack integrated error detection and correction mechanisms. Therefore, any endogenous flaw detected in the system, as well as any exogenous shock that the system cannot respond to due to a lack of operative resources, compromises the entire web of components and their relationships and functionalities.

How, then, does the system metabolize an error?

In case of complex technological systems, safety studies – where safety implies the system's capacity to avoid disaster, even though it is acknowledged that complex systems continuously and inevitably fail – identify the skills of operators at the "edge of the envelope" (Cook, 1998) as crucial. In these cases, error detection and correction are often closely related to (often non-demonstrable) knowledge developed through extensive close contact with both the system and various continuous failures.

However, sociotechnical systems, like cities or regions, are categorically more complex than relatively closed complex technological systems, like nuclear reactors – in big complex sociotechnical systems, like cities, the boundaries of systems and subsystems are porous, and the values according to which the systems and subsystems are optimized, as well as the related functions and, finally, rules, are plural and often incommensurable.

For a start, in highly complex sociotechnical systems, the key error metabolism mechanism is the capacity to collect and integrate unique and feedback information, especially unpredictably distributed unique and feedback information – a typical example is the experimentalist epistemic model of democracy, which preserves free, open deliberation and, crucially, dissent and feedback after the implementation of a given public policy (Anderson, 2006).

The design process requires expert knowledge about individual elements and the relationships between components within the system, as well as research methods for distinguishing the important aspects of these elements and relationships. Therefore, the principal step in every system design process is to collect relevant information, which requires qualitative field research – interviews, ethnographic, and participatory research investigations. Also, after collecting the relevant information, the initial design of the system has to be presented to the main process stakeholders, individually and/or as a group, primarily in order to discover "hidden profiles" (D'Agostino, 2010), i.e., relevant information that is implied, and thus remains undetected. However, crucially, *continuous experimentalism* – open deliberation and open channels of communication for unique information, normative innovations, and, generally, feedback on tested solutions – *must be integrated in the design as a property of the system*. Therefore, an inclusive participatory design method must facilitate a) collecting key information about required functionalities, but also b) developing the most efficient structures of continued substantial participation in unending reform and adaptation. Participation, if reduced only to research before or during design, where the design itself doesn't ensure functional, substantial participation, is a typical recipe for system catastrophes and frail systems.

The second key mechanism of error metabolism in highly complex sociotechnical systems is the concept of "risk-spreading" (and "bet-hedging"), mainly developed in the philosophy of science by Thomas Kuhn (1977) and Fred D'Agostino (2010) and in the works on the division of cognitive labor (Weisberg and Muldoon, 2009). The key insight is that any collective research, dynamic problem-solving (used to resolve difficult problems), and learning process requires an essential tension between 1) the conservative approach, that "exploits" the established, and best-so-far, theory, allowing a high level of coordination among geographically dispersed researchers, and 2) risky innovation that "explores" potential new theories. Betting only on any single strategy, including, and this is crucial, the best-so-far, leads to being stuck in a suboptimal situation.

A federated system structure is the organizational principle of risk-spreading, where the choice of theory, collecting evidence, and testing normative and conceptual solutions (strategies) are localized under a defined minimum set of common global rules, including rules for efficient global upgrades if a better common rule is discovered. Therefore, federated systems are not decentralized, but polycentric – they host a number of different centers on different levels of the system, including a global center which, however, doesn't perform the command-and-control function, but safeguards the minimum set of rules needed to maintain polycentricity and learning, and to secure the capacity for systemic upgrades when a better new global rule for maintaining polycentricity and learning is discovered. In addition to enabling learning in general by preserving the essential tension between exploitation and exploration through localized institutional experiments, polycentric systems are more resilient because it is more difficult for an error in any part of a polycentric system to propagate throughout the system, and because they enable the development of degeneracy (Whitacre, 2010), i.e., the capacity of different components to perform various sets of functions, including some that overlap, which allows, when one component fails, another component of the system to take over the necessary functions.

In conclusion, polycentric systems are particularly well-suited for the aforesaid harvest of unique and feedback information since the principle of subsidiarity – dictating that problems should be solved at the lowest, most local level of impact – is the main principle of polycentricity. The subsidiarity principle reintegrates (to a degree, in a qualified manner) insights from safety studies of complex technological systems – in complex sociotechnical systems, individuals on the "edge of the envelope" of a problem usually possess information crucial for solving the problem. However, due to their structure including different centers with various combinations of overlapping functions, rules, and values, the polycentric systems (as a rule, in case of high-quality design as well) also provide protection from local mafias by giving the agents access to alternative (redundant) institutions on different levels of the system.

Finally, as a key mechanism associated with risk-spreading, the development of "technology of foolishness" (March, 1971; Larsen, 2010) – sociotechnical solutions that allow redundant, far-away (from the dominant, best-so-far practice) experiments without comprehensive justification – should also be mentioned here. The technologies of foolishness, among other things, also serve the purpose of creating an archive of eccentric mechanisms, potential new goals and functions, and "solutions", which can be tapped in future iterations of the system and the condition of the world.

Many contemporary over-stabilized social-technological systems suffer from the lack of all three families of error metabolism mechanisms.

Error harvest, as a design-driven teaching method for specialists in urban studies, largely fits into all these error metabolism families; however, in our opinion, linking it to the technologies of foolishness is crucial. As a teaching method, error harvest is not purely speculative, in the sense of helping designers develop their predictive capabilities, since it can be used to improve understanding and development of alternative "here and now" design solutions. Error harvest primarily aims at a) understanding and maximizing detection of inherent flaws, unintended consequences, and exogenous shocks, and b) designing mechanisms for a productive utilization of identified inherent flaws, unintended consequences, and exogenous shocks. Of course, this does not mean that designers will be able to identify all inherent flaws, unintended consequences, and exogenous shocks. Furthermore, error harvest can never, under any conditions, substitute all the classic key learning and adaptation mechanisms used for developing systemic capacity for adaptation and reform (sometimes even radical) when confronted with a new complex problem

The goal of error harvest is to develop a "calibrated view of hazards" (Cook, 1998) through the process of explication of and familiarization with the characteristics of the flaws, consequences and shocks *that can be predicted* and to develop the sensibility for dynamic adaptation, systematic learning and hidden multidimensions and multifunctionalities of the segments of open, highly complex sociotechnical systems by providing training in the development of mechanisms within the system that can exploit predictable flaws, consequences and shocks to promote target values. Although this is, in a sense, a modest ambition, there's nothing like it in contemporary system design practices (deeply epistemically compromised as they are), and the methodological repertoire of the current system design theory (although significantly advanced) doesn't include the aforesaid method. Thus, error harvest represents a significant contribution to the advancement of the discipline of system design.

3.2. Situating the Method in the Context of Design-Driven Spatial Practice

Design-driven spatial practices are part of system design where a specific physical space dictates the conditions and results, and the system is characterized by some form of spatiality, i.e., we are talking about a spatial system. At the same time, the contemporary context, characterized by complex problems, multiple crises, and unpredictably distributed disasters, also materializes in actual physical space. This context, as well as the materialization of these characteristics, necessitates a redefinition of the types of design disciplines. One of the key developments in this trend is the redefinition of a variant of the resilience theory, which identifies optimization through quantification (Paans, 2019) as the dominant method for responding to the observed situation. However, in general, quantification-based optimization presupposes epistemically unjustified intelligibility and countability of elements and relations, and, specifically, in design-driven spatial practices, equates the level of control and flexibility (…) of tools with full knowledge of the problem structure (Paans, 2019:97). One response tactic consists of limiting the use of quantification-based approaches to design, combined with introducing qualitative criteria for spatiality (Paans, 2019).

Lydia Kallipoliti sees the roots of this new, richer disciplinary redefinition in ecological design, whose history, value systems, and dominant concepts are presented in her recent book *Histories of Ecological Design: An Unfinished Cyclopedia* (Kallipoliti, 2024). The motivation for such an undertaking can be illustrated by providing a summary overview of the tasks defined on the basis of detected weak points of the disciplines of architecture and design:

1. to find an alternative to the prevailing definition of design as a discipline that primarily produces static final forms and shapes;
2. to model the production system as circular and regenerative, not linear and irreversible;
3. to understand ecology as a link between living organisms and their surroundings;
4. to recognize quantitative and parametric spatial data models and predictions of future states presented as digital simulations as the result of the need for control, and treat them as just another fallible value system;
5. to recognize climate change as an embodied and lived experience, not as a distant abstract phenomenon.

In parallel with defining the tasks listed above, Lydia Kallipoliti has revised the term "ecological" and provided her own definition, or interpretation, of ecological design:

> *"…ecological design is an ideational and philosophical system of viewing the world of ideas, information, and matters as flow rather than as the accumulation of discrete objects. More than a material system, it signals the migration of life through the conversion of one thing to another."* (Kallipoliti, 2024:23)

Architect Keller Easterling contributed to further enhancing the relevance of spatial practices, beyond the design of objects and in opposition to the modernist technocratic ideas of precision and correctness. Viewing space as a "mixing chamber for the languages of many disciplines" (Easterling, 2022, also see 2020), or "a medium, *medius*, middle or milieu", Easterling introduced the term "medium design", which focuses on background relationships, dispositions, context and webs of relationships at a given moment and through time, instead of isolated objects outside time. This critical stance towards deterministic solutionism promoting unique and singular solutions that, according to Easterling, represent a position of weakness in front of political power, points to the need for design in the service of political activism. Medium design uses hacker system tools as subtle and cunning deceptions positioned between things, which annoy the dominant power like pesky flies. Easterling sees potential in problems and discarded things, and this potential activates the method of medium design by multiplying and combining them. She introduces the concept of errors and remnants as elements undesirable for the dominant power and as potent resources for other needs, to be directed by the medium designer. Similarly to Gissen, who views subnatures as spaces of a different architecture, Easterling, from the position of resistance to the prevailing power, recognizes an interest in that which has been discarded, and which is not interesting to the dominant power. Here, the author primarily focuses on capital-driven design and views the recombination of excess detritus of capital (errors) as a transformation of this excess detritus into tools for medium designers.

An exhaustive review of error in architecture can be found in the works by Francesca Hughes (2014, 2023). Error, according to Hughes, is a productive category that opens the possibility for a critical review of precision in architecture, while being a byproduct of that same precision. Similarly to Paans, Hughes recognizes the dominance of simulations and quantification in the discipline as a crucial epistemic trap for contemporary spatial practice, where redundant and, ultimately, false precision is the symptom of a fear of error in architecture materialized in the real world. The development and refinement of digital tools leads to a fetishization of precision; the resulting epistemic distortions are best illustrated by extreme zoom-in tools that facilitate excessive detail, thus effectively distancing the designer from the architecture materialized in the real world, where such level of detail has no relevance at all, while the relevant causalities and, ultimately, affective materialities play out in other scales. This domination of control and quantification in spatial practices ultimately prevents understanding of complexity and, consequently, understanding of error as a usable element.

Hughes sees the potential for reforming this epistemic "dead end" of architecture in architectural education that does not focus only on normative measurement systems and optimization through quantification, but also, among other things, teaches the students to understand and use "the uncertain, the anomalous and the risky" (Hughes, 2022). In this context, error harvest can be used as one of the methods for such critical education in a non-ideal world.

3.3. Theoretical Foundations of the Method in Broken World Design

In his *Rethinking Repair*, Steven J. Jackson (2014) introduced the concept of broken world thinking (which can also be understood as "thought/design in a broken world" and "thought /design by means of a broken world") by asking what happens when we take erosion, breakdown and decay, instead of novelty, growth and progress, as the starting points for design?

Jackson, and other key authors who developed the paradigm of broken world design further, base their approach on facing the obvious –dominant political and sociotechnical systems are in critical crises that we now recognize as developments inherent to their design. Under this onslaught of crises, "our patching will not hold. The storms of this century are too severe." (Moe and Friedman, 2020)

The problem, however, is not simply historical, but epistemological, or, even more crucially, ontological. As noted by Fred D'Agostino (2010), the nature of our epistemic limitations is ontological – in other words, no agent, be it biological or artificial, can overcome the inherent complexity, unpredictability, and imperfection of the world. Our ignorance is "incurable" (Hayek, 1945). The world will always resist our conceptualizations and design, and epistemically, we follow the real world through the revolts of material reality against our attempts to understand and control it.

This understanding leads us to approach design by focusing on the inevitability of breakdowns and decay.[2] Error harvest obviously belongs to the new paradigm of broken world design, which posits that every system contains its own inherent breakdowns and decays, be it endogenous or emergent in contact with other systems, and that designers have to “train the eye” to engage in design by building upon flaws and errors of the “as-found” state and, also, to design their solutions so that the designed state includes the potentials for a productive transformation of future breakdowns and decay. The designers should also always keep in mind their own epistemic limitations – including the limitations in predicting future states. However, this mindset shift opens up the possibility of achieving a qualitative difference in design – instead of the hubris of over-stabilized systems of countable and legible elements and relationships, it emphasizes humility and open systems with unknown dynamics by incorporating channels for free interconnections, redundancies, and other mechanisms for adapting to future breakdowns and decays. The paradigm of design changes and becomes “a technics shaped not by arrogant domination but rather by humble cooperation” (Moe and Friedman, 2020).

3.4. Theoretical Foundations of the Method in Non-Ideal Institutional Epistemology

For most of the (at least) canonical history of thought, classic epistemology has focused on exploring the conceptualization of knowledge and the ideal rationality of an isolated individual subject.

However, the discipline has undergone a thorough change under the pressures of 1) critical theory and sociology, and their insights revealing that science and broader epistemic practices are largely influenced by non-epistemic and dominantly oppressive, and imperialistic, systems of power (Alcoff, 1996), and 2) the developments in the field of political economy, that reject the selfish, perfectly rational subject possessing complete information as the model for the agent, replacing it with a boundedly rational, epistemically suboptimal, normative agent (D’Agostino, 2010; Boettke, 2018), and positing a comparative analysis of the epistemic powers of institutional systems as the primary focus of research in political economy (Ostrom, 2005; Boettke, Tarko and Aligica, 2017).

The key research programs (in the broad sense) that form the basis for the development of non-ideal epistemology are 1) studies on the division of cognitive labor, and 2) critical social epistemology. The studies on the division of cognitive labor involve

[2] It is worth noting that this understanding is also closely aligned with key insights from safety studies in complex technological systems – because, always, as Richard Cook directly points out, “complex systems run as broken systems.” (Cook, 1998).

formal research, primarily through agentic models, examining emergent collective properties by determining the properties of the agents and the rules of their behavior (see, e.g., Zollman, 2010; Smart, 2018; Wu, 2023). Standpoint theory and epistemic injustice theory are central examples of critical social epistemology, itself largely the result of advancements in feminist theory, race and systemic racism theory, and postcolonial and decolonial theories. Broadly speaking, standpoint theory claims that marginalized members of society have an epistemologically privileged insight into the functioning of the institutional system (Hartsock, 1983; Wu, 2023), whereas epistemic injustice theory analyzes the forms of delegitimization of epistemic contributions of individuals based on their affiliation with a marginalized group, as well as the forms of preventing marginalized groups from developing a conceptual apparatus for understanding, analyzing and communicating the injustices to which they are systematically subjected (Fricker, 2007). Both theories, crucially, "put flesh on the bones" of formal insights, identifying substantial threats to the development of an epistemically reliable plurality.

Non-ideal epistemology rejects idealizations of individual epistemic agents and institutions (McKenna, 2023). In this context, institutional epistemology is non-ideal epistemology focused on research and intervention at the system level, rather than the individual level (Anderson, 2006). Alongside formal and critical social epistemology, comparative analysis of the epistemic properties of institutional systems in political economy (Ostrom, 2005; Boettke, Tarko and Aligica, 2017), as previously mentioned, was also crucial for the development of institutional epistemology.

The key assumptions of institutional epistemology, shared by different schools of thought within the discipline, are as follows:

1. Individual epistemic agents are necessarily epistemically suboptimal (they lack sufficient information, make inferential errors, and conserve flawed normative strategies) and normative (their approach to the world and the problem is mediated by normative conceptual strategies, where sharing a normative strategy implies sharing suboptimal locking, errors, and/or blind spots).
2. Knowledge is an irreducibly social phenomenon

2.1. Collective epistemic virtues are irreducible to individual epistemic virtues, especially in new hard problems ("independence thesis", see Mayo-Wilson, Zollman and Danks, 2011), but also in tame problems, where individual epistemic flaws enable the development of cumulative culture (Levy and Alfano 2020)

2.2. Collective epistemic virtues are more conducive to finding knowledge than individual ones (see 1.)

2.3. The collective and individual search for knowledge is guided by normative strategies and institutions.
2.4. Epistemic reliability is a function of the institutional system that organizes the search for knowledge, and not a function of individuals.
3. Governance is a complex, uncertain and difficult problem (Page 2008, D'Agostino, 2010; Mayo-Wilson, Zollman and Danks, 2011; Gaus, 2016).
4. The comparative standard of the epistemic powers of an institutional system is its error metabolism (Wimsatt, 2007) – how reliable is it in recognizing and revising errors?

The error harvest method also draws upon the theoretical background of non-ideal institutional epistemology in several significant ways, and we can present three crucial aspects here as theses incorporated into the development of the error harvest method.

1) Systems are complex and dynamic and, consequently, not predictable or static, and do not contain countable and legible elements and relationships. Error harvest presupposes scenarios with various potential dynamics (in particular, causality among initially unconnected factors) and illegible elements, thus training the designer to think under non-ideal conditions of complexity (where the designer will never be able to presuppose all dynamics or elements, not even the significant ones, but will approach the design with epistemic humility), as well as to develop a repertoire of systemic solutions for transforming hidden flaws into potential sources of productivity, robustness and resilience.

2) Systems are always unfinished and imperfect, and every system exists within and in contact with other systems. Error harvest provides training in the development of scenarios and the design of mechanisms that will utilize potential developments, endogenously emergent flaws, and flaws that emerge from interactions with certain other systems[3], for productive purposes and/or robustness and toughness.

3) Design is not aimed at determining the end-state of the system; it aims to shape open systems, primarily determined negatively (by ensuring protection from certain dynamics) and locally (by determining functions and dynamics of certain subsystems). Error harvest continuously treats the system as open, and the designer as epistemically limited. Crucially, error harvest trains the designers to look for and identify adaptation potentials in open systems, where openness itself becomes, rather than a threat, a resource for systemic upgrades, and social and institutional learning.

[3] It is worth adding an important note about 'framing' in the process of designing a particular subsystem, which allows the designer to provisionally categorize the relevant elements usable in the design (Moe and Smith, 2012:5). By including potential stipulated exogenous processes as potential errors/tools of the framed subsystem, error harvest facilitates further examination of framing in the given project.

4. Examples of Application of the Method in Urban Studies at the University of Rijeka

The final part of this paper presents two sets of results obtained by using error harvest as a methodological exercise in the workshop that combined two course units, Epistemic System Design and Research-Based Design Studio. The work of the first generation of students, enrolled in the study program with the thematic framework Resilient Campus in the academic year 2022/2023, is presented as the first example, and the second example presents the work of the second generation, enrolled in 2024/2025 with the thematic framework Waterworld Futures. It should be noted that, in the 1st generation, the working title of the error harvest methodological exercise was *Disequilibrium Utility*.

4.1. Year of the Pig

Resilient Campus, the thematic framework for the first generation of students of Urban Studies, involved a rethinking of the space of the Rijeka University Campus on Trsat, almost 20 years after the conceptual urban and architectural design competition that the 2005 Detailed Urban Plan of the University Campus and the Clinical Hospital Centre on Trsat is based on. A detailed urban plan is a lower-level spatial plan that defines all urban planning and architectural conditions for future development and construction within the scope of the plan. Given that only about 40% of the plan was implemented before the aforesaid methodological exercise took place, with a considerable temporal and critical distance, the University of Rijeka decided to entrust Urban Studies with the task of performing a new spatial analysis and preparing new project proposals for the University Campus through the lens of contemporary ideas and spatial needs for a better future. The attribute 'spatial resilience' was the goal of the above task. The term *resilience* denotes the property that allows a system to absorb and utilize a disturbance or even turn it into a benefit (Holling and Walters, 1976).

Before the exercise, through coursework and site visits, the students familiarized themselves with the physical space of the University Campus, and completed the required reading, the book *Subnature: Nature Other Environments* by David Gissen.

The task was to achieve one or more resilience goals in the space of the University Campus in one of the three proposed scales, using errors as tools. The errors, i.e., tools, included all the subnatures from Gissens's book: atmospheres (dankness, smoke, gas, exhaust), matter (dust, puddles, mud, debris), and lifeforms (weeds, insects, pigeons, crowds), as well as transiency of the space (crowded, vacated, impermanent). The proposed scales included three spatial scales: small (segment, unit, pixel – e.g., students' room, classroom etc.); medium (a group characterized by a common characteristic – e.g., groups of faculties, green areas, common areas, and others), and large scale (zone, unit – e.g., neighborhood). Finally, resilience was operationalized through the following goals: 1) redundancy (e.g., redundant spaces, redundant service providers, parallel institutions, and similar, 2) deplanning or deprogramming (e.g., enabling randomness), 3) creating new communication channels.

All proposals had to be presented in the following format: 1) short text, and 2) illustration on A3 paper in portrait orientation. All the materials we present here were prepared by the students, with the textual descriptions adapted for the purpose of this paper.

Although all student projects proved to be both successful and engaging, this paper presents the project that most effectively exemplifies the educational value of the exercise: the project titled *Year of the Pig* by Ines Marasović, Ana-Marija Vašiček and Dorian Vujnovića.

In the *Year of the Pig*, these errors are used as starting points: a) an increase in the population of wild boars in the rural area of the County, and b) strong gusts of bora characteristic of the wider area of the University Campus on Trsat. Focused on the large scale, the project identifies, in the spatial planning stage, an abandoned, wild area behind the built campus as the primary site for the instantiation of the proposed solution. The project aims to facilitate the development of new communication channels, namely, it elaborates a proposal for building interconnections among various constituent units of the University through a joint research and development project (and different associated subprojects). The central proposition is the elaborated joint research and development project involving different constituent units of the University – developing the production of dry-cured ham or *pršut* from wild boar meat dried by the bora in the abandoned, wild area behind the campus. As the students put it:

> *"Phenomena that are primarily negative, in this case, the problem of the bora and wild boars, can lead to cooperation among different faculties in preparing expert papers. Seemingly disparate faculties examine the proposed problem through the lens of common topics: Faculty of Tourism and Faculty of Civil Engineering – meat curing houses as a new tourist typology; Physics and Informatics – evolutionary algorithms describing wild boar breeding; Humanities and Social Sciences, and Fine Arts Academy – the pig in art from the Middle Ages to the present; Law and Psychology – expected gifting of pršut as the symbol of corruption."* (Marasović, Vašiček and Vujnović, *Year of the Pig*, project report)

The above project clearly reflects the fundamental characteristics of error harvest. The increasing wild boar population is treated as a characteristic error at the county level, while the gusts of bora represent a characteristic error in the context of the University Campus. Linking the two errors from different scales is a particularly praiseworthy aspect of this proposal, as it demonstrates thinking in terms of the system rather than in terms of an isolated location, using the error on the campus level to utilize the county level error. However, in this regard, it is crucial to note that the goal of the project was to develop cooperation among the constituent units at the Campus, which rarely communicate and cooperate. Thus, the students did not specify their project goal along the lines of "solving the problem of the increase in the population of wild boars in the Primorsko-Goranska County" or similar. Instead, they *exploited* this population increase to open new channels of communication among different constituent units of the University, thereby strengthening inter-institutional cooperation.

Figure 1.
Illustration for *Year of the Pig*

students: Ines Marasović, Ana-Marija Vašiček, Dorian Vujnović, 2023

4.2. End-Down Respirator

The comprehensive thematic framework for the 2nd generation, *Waterworld Futures*, a guide for the students in their work, was defined on two levels: water, both the term and the concept (fresh, saline, brown, ocean, sub-water, coastal population, etc.), and the geopolitical moment of positioning Rijeka and the region as the future hub where several infrastructural corridors of the water and the land world intersect. In late 2021, Rijeka, with its surrounding area, was once again recognized as a cargo port of great economic and strategic importance in shaping global dynamics and logistics, and, therefore, its improvement has become one of the country's priority investments. The narrative that urban development of the city is proportional to the development of its port is only partially correct since the port and the city have historically developed as separate entities. To transform the narrative about the future urban development of Rijeka and its surrounding area, those who live and work in the city and those who make decisions about the city need a shared vision of the future. At the same time, multidisciplinary knowledge of various experts who transform the visions into development policies is needed to ensure that these visions address the challenges of climate change and ongoing crises.

The task for the second generation involved the following scales: a) the marine area of Rijeka (architectural scale), b) the coastline of Rijeka (urban design scale), c) the waters of Kvarner (urban design and planning scale), d) a combination of the above. The goal was to create spatial, institutional, and/or social conditions that foster collectivity. It was set based on the discussions that took place within Epistemic System Design, where the participants defined and elaborated the operational hypothesis that political, economic, and cultural conditions hindering the development of collectivity and collective action were one of the key reasons for class-based monopolization of power and, consequently, an obstruction to systemic learning. Finally, in this iteration, the tools (i.e., errors) were just an open-ended list of suggestions, allowing the students to identify and propose the errors they considered particularly representative of the context and usable for the purpose of the exercise. The proposed errors included: too much or too little water (fresh and salt water); an excessive number of yachts; a decline in Rijeka's population; the allocation of a substantial part of Rijeka's coastline for a container terminal; and non-native and potentially invasive animal species arriving by ship.

As in the previous example, all proposals had to be presented in the following format: 1) short text, and 2) illustration on A3 paper in portrait orientation, and all the materials we present here were prepared by the students, with textual descriptions adapted for the purpose of this paper.

Also, as in the previous example, we would like to note that all student projects proved to be both successful and engaging, and that the student project presented in this paper was selected because it can illustrate some of the key aspects of the exercise.

The project to be discussed here is *End-Down Respirator* by Tomislava Blatnik, Marin Nižić, Bruno Stemberger, Sara Stojaković, and Sanjin Vranković.

The title *End-Down Respirator* was envisioned as an antonym of the popular phenomenon of the so-called *start-up accelerators*. The project examines the case of the 3. Maj shipyard in Rijeka, widely discussed over the last several decades, mostly due to the constant need for state aid to continue its operations. In *End-Down Respirator*, 3. Maj is examined as an example of error in the context of Rijeka's "waterworld", but, rather than correcting the error, the project uses 3. Maj for the purpose of developing "an innovative social economic model using the error as a fundamental value" (Blatnik, Nižić, Stemberger, Stojaković, Vranković, *End-Down Respirator*, project report). Namely, the project proposes that various parts of the shipyard complex be used for spatial development aimed at "experimentation, failures and worker solidarity" (ibid.) where individuals and groups can "freely 'fabricate errors' through work, art, craftsmanship and technological experimentation" (ibid.), as well as through leisure and "wasting time" (ibid.). Crucially, the project proposes a redefinition of state aid, so that financial interventions by the government cease to be "rescue measures" and become "support for a free production of failures" (ibid.).

End-Down Respirator is an illustrative example of the error harvest method for several reasons. By challenging the typical comments stating that the government should stop providing capital injections to the shipyard, the proposal demonstrates how error harvest can be used to question and reconceptualize the assumptions and beliefs that have become deeply ingrained in the public discourse and culture. However, the key reason why this proposal is considered especially illustrative has become evident during the workshop process itself. During the first presentation of their idea in the workshop, the students focused on examining 3. Maj as an error to be corrected, in line with the typical comment mentioned above. In their first critical evaluation of the idea, the workshop facilitators thus had to focus primarily on the central reconceptualization of the treatment of error as the very purpose of the method. Then, for the remaining part of the workshop, the students had to reject conventional wisdom in their understanding of the phenomenon of 3. May and focus on exploring the way in which the phenomenon can be used for the purpose of developing collectivity. Their project proposal is the result of this *shift in thinking* – 3. Maj is not treated as an error to be corrected anymore, but as an error a) that can only be identified from the perspective of a very specific inherited political economy paradigm, b) that has to be reconceptualized outside that paradigm, and c) that can be (speculative and symbolically) utilized for the very purpose of changing the inherited paradigm.

Figure 2.
Illustration for *End-Down Respirator*

students: Tomislava Blatnik, Marin Nižić, Bruno Stemberger, Sara Stojaković and Sanjin Vranković, 2025

5. Conclusion

Error harvest is a simple methodological exercise that allows researchers and practitioners in the field of sociotechnical system design to train in analyzing and acting in a complex, non-ideal, broken world. It provides students with the experience of thinking (including dialogical thinking in group work) about errors as resources for designing systems and solutions. Its value lies in part in its simplicity. The method is easy to explain and understand, and it can be applied when working with students across disciplines and educational levels. It is also adaptable – it can be easily upgraded with new elements in new contexts. A relevant example of the method's adaptability and wide applicability is the development of the project *Intelligence of Errors*, resulting in the artistic work presented in the Croatian Pavilion at the Venice Biennale, the 19^{th} International Architecture Exhibition. *Intelligence of Errors* was created by curator Ida Križaj Leko and the team of authors Ana Boljar, Jana Čulek, Iva Peručić, Marino Krstačić-Furić, Ana Tomić, and Marko-Luka Zubčić. Following the public call, at the proposal of the Selection Committee (architect Tonči Čerina [Chairman]; Vjekoslav Gašparović, Head of the Expert Council of the Croatian Architects' Association, Prof. Karin Šerman, PhD, Faculty of Architecture at the University of Zagreb; and Maja Kocijan, Director of the Museum Documentation Center), the Minister of Culture and Media accepted *Intelligence of Errors* as the project to represent Croatia at the Venice Biennale. Given the complexity of the project, a more detailed elaboration of *Intelligence of Errors* would require a separate article. It is mentioned here only as a note to illustrate the openness and potential applications of error harvest beyond the educational process. However, we believe that the key value of the method lies in education, where it opens up the possibility for the development of new generations of researchers and workers across various disciplines who have a deeper understanding of the complexity, non-ideality, and brokenness of the world and act in accordance with this deeper understanding.

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Izvorni znanstveni rad

Žetva greške: Metoda dizajna sustava pod ne-idealnim uvjetima

Marko-Luka Zubčić
Institut za filozofiju u Zagrebu, Hrvatska
e-mail: mlzubcic@ifzg.hr

Ida Križaj Leko
Sveučilište u Rijeci, Urbani studiji, Hrvatska
e-mail: ida.krizajleko@uniri.hr

Sažetak

U ovom članku predstavljamo "Žetvu grešaka", novu metodu za edukaciju i treniranje dizajneric/a kompleksnih društveno-tehnoloških i prostornih sustava (primjerice, urbanih cjelina) pod ne-idealnim uvjetima. Žetva greške dizajneric/e suočava s ekspliciranjem inherentnih mana i predvidljivih (iako možda rijetkih ili malo vjerojatnih) šokova nađenog sustava, te predstavlja vježbu reinterpretacije tih mana i šokova dizajnerskim rješenjima u produktivne mehanizme sustava (pri čemu je produktivnost definirana unutar vježbe poželjnim ciljevima koje mehanizmi trebaju ostvariti). Metodu u članku predstavljamo te elaboriramo unutar i u odnosu na polja prostornih praksi, dizajna sustava, dizajna slomljenog svijeta te ne-idealne institucijske epistemologije. Zaključno predstavljamo dva različita primjera upotrebe metode.

Ključne riječi: dizajn sustava, neidealna teorija, slomljeni svijet, edukacija, institucijska epistemologija.