STRATEGIC DESIGN RESEARCH JOURNAL

From Operational Conditions to Design Knowledge: Situated Problem Reformulation in an Infrastructure-Constrained Development Context

Klaus Kaulicke [a] | Lázaro V. Cremades [a] *

[a] Universitat Politècnica de Catalunya, Department of Project and Construction Engineering, Barcelona, Spain
* Corresponding author: lazaro.cremades@upc.edu

ABSTRACT

Design interventions in development contexts often treat local conditions as information added after a problem is defined. This article examines how situated operational evidence becomes epistemically active when it creates friction with an initial assumption and is interpreted into a reformulation of the problem. Using the O-Waste electric mobility component in The Gambia, it traces four episodes involving routes, payload, procurement, and autonomy. The study proposes a sequence linking initial assumption, evidential friction, situated interpretation, design consequence, and validation boundary, distinguishing design reasoning from claims that still require operational validation.

Keywords: Industrial Design, Situated Knowledge, Design Epistemology, Operational Evidence, Problem Reformulation, Development Contexts.

INTRODUCTION

Contemporary industrial design addresses problems that cannot be reduced to the functional, reproducible, and technically optimized product. In fields such as sustainability, mobility, infrastructure, and territorial development, artefacts must be evaluated not only through technical performance, but also through the social, cultural, productive, energetic, and institutional conditions that make their operation possible. This has encouraged systems-oriented design, Transition Design, Systemic Design, situated research, and decolonial perspectives, which understand design as intervention in interconnected arrangements rather than the production of isolated objects (Irwin, Tonkinwise, & Kossoff, 2020; Sevaldson, 2013; van der Bijl-Brouwer et al., 2024).

This shift is especially relevant in infrastructure-constrained development contexts, where direct technological transfer often produces short-lived results. A solution may be mechanically efficient yet operationally unviable when it does not correspond to material practices, maintenance capacity, institutional coordination, or available knowledge. Under these conditions, the design problem cannot be defined only before implementation and then adapted through additional contextual information. It must remain open to reformulation as operational evidence reveals that its initial categories, assumptions, or criteria are insufficient. Decolonial perspectives reinforce this concern by questioning how development, progress, innovation, and efficiency are defined, and whose knowledge is authorized within intervention processes. External technologies may reproduce asymmetrical relations when local capabilities and organizational practices influence implementation but do not alter the terms through which the problem itself is understood (Abdulla et al., 2019; Schultz et al., 2018). The relevant issue is therefore not simply whether context is considered, but whether situated experience can become consequential for design reasoning.

Against this background, the study examines the electric mobility component of Re-circulating O-Waste in The Gambia's Food Supply Chain. It does not evaluate the complete O-Waste system, but focuses on the operational connection through which organic waste is collected from municipal markets and transferred to treatment. The case reconstructs how a task initially framed as vehicle selection was challenged by route conditions, load handling, maintenance, supply, charging, monitoring, and institutional responsibility.

The study asks: how does situated operational evidence become epistemically active in the reformulation of industrial design problems in development contexts? To address this question, the article analyses project records, workshops, technical studies, supplier research, previous experience, and implementation materials to identify when evidence created friction with an initial assumption, how that friction was interpreted, which design consequences followed, and what remained open to validation.

The central argument is that a designer can justify problem reformulation only by showing how a situated condition challenges an initial assumption, why that assumption becomes insufficient, and which traceable design consequence follows. They become epistemically consequential when their interpretation reveals the insufficiency of an existing formulation and produces a traceable change in criteria, decisions, responsibilities, or validation boundaries. In the case examined, electric mobility was reformulated from an isolated vehicle-selection task into the configuration of a specific operational arrangement intended to sustain collection and transport within a wider circular process.

1. SITUATED OPERATIONAL EVIDENCE AND DESIGN KNOWLEDGE

This section establishes the epistemological basis for distinguishing contextual information from situated evidence. Its concern is not how much contextual knowledge designers collect, but when observations, documents, workshops, technical comparisons, or previous experience become consequential within design reasoning.

1.1. Design practice as situated knowledge production

Design practice cannot always be understood as the application of knowledge produced elsewhere. Relevant understanding often emerges while a project is already developing, as people, documents, materials, institutions, and technical alternatives are brought into relation.

Kaszynska and Kimbell (2025) describe design-practice research through situated understanding, networked knowledge production, communities of validation, and identifiable knowledge outcomes. Their formulation treats knowledge as relational rather than as the product of an isolated designer later transferred to a passive setting. Practice becomes epistemically relevant when the understanding it produces can be articulated, examined, and connected to decisions.

This position changes how evidence is conceived. Knowledge does not reside entirely in specifications, reports, participant statements, professional expertise, or field observations. It emerges through the relations established among them. A report may document a delay, a workshop may identify an operational concern, previous experience may reveal a plausible risk, and a technical comparison may show how that risk affects a decision. No source is necessarily conclusive in isolation; its significance develops through interpretation and comparison.

Hornbuckle, Page, and Nogueira (2024) similarly emphasize the exploratory and responsive character of design research. Questions may evolve as practice brings different forms of knowledge into relation. This does not imply an absence of direction. Rather, the original framing may itself become an object of inquiry when situated experience exposes assumptions that had remained implicit.

A retrospective description of activities does not automatically constitute knowledge production. The relevant analytical task is to reconstruct how engagement with a situation changed the categories through which decisions were made. In the present study, O-Waste provides a situated example of this process, while the analysis remains limited to the electric mobility component connecting market collection with subsequent treatment.

1.2. From contextual information to epistemically active evidence

Contextual information and situated evidence are not equivalent. Contextual information describes the circumstances surrounding an intervention, including geography, infrastructure, institutions, technical capability, material practices, and organizational routines. Such information may remain descriptive without changing how the intervention is conceived.

Situated evidence emerges when an experienced or documented condition creates friction with an assumption embedded in the initial problem formulation. This *evidential friction* does not refer simply to difficulty, disagreement, or unexpected information. It occurs when available material reveals that an existing category, criterion, or representation is insufficient for guiding the intervention.

A workshop does not become evidence merely because it occurred. A field observation does not become evidence simply because it was recorded. A procurement delay does not become evidence solely because it affected the schedule. Epistemic significance depends on whether such material challenges an assumption and can be interpreted into a change in problem framing, criteria, decisions, responsibilities, or validation needs.

Klein et al. (2024) make a related argument in their account of situated modelling. Models and representations are shaped by purposes, positions, assumptions, and decisions about what becomes visible. Although their work concerns modelling, the epistemological implication also applies here: information does not determine its own significance. Meaning emerges through the relations and purposes within which it is interpreted.

Situated operational evidence is therefore defined as a documented material, technical, organizational, institutional, or experiential condition whose interpretation reveals a limitation in the initial framing and changes how the design problem is understood, which consequences become relevant, or what remains open to validation.

The expression *epistemically active* identifies this transformation. It involves three connected movements:

- First, evidence generates friction with an initial assumption. Categories such as mobility, payload, procurement, maintenance, or autonomy may appear stable until operational experience reveals that they do not adequately represent the intervention.
- Second, interpretation identifies what that friction means for the problem. Evidence does not determine a solution directly; it reveals which category has become insufficient, which relation must be incorporated, or which criterion requires revision.
- Third, the interpretation must produce a traceable consequence or validation boundary. A reformulation may redirect an alternative, modify an arrangement, redistribute responsibility, or identify a claim that cannot yet be supported.

This distinction avoids two simplifications. Contextual data do not automatically constitute design knowledge, but neither does situated evidence dictate a technical response. Interpretation remains necessary and must be made visible. The analytical focus is therefore not merely the movement from information to decision, but the sequence through which an initial assumption encounters evidential friction and is reformulated.

Within the mobility component examined here, this movement concerns the shift from selecting a vehicle according to nominal specifications toward configuring an operational arrangement capable of sustaining collection and transport. Routes, handling, maintenance, charging, supplier relations, and institutional responsibilities become epistemically relevant when their interpretation changes that task.

1.3. Positionality and epistemic responsibility in development contexts

Situated evidence does not enter design neutrally. Documents are produced for particular purposes, observations are made from specific positions, and professional interpretations are shaped by disciplinary and institutional assumptions. Knowledge generated through practice is therefore partial rather than detached or universally valid.

This issue is especially important in development contexts, where interventions have often followed a one-directional model: technologies and formal expertise are produced elsewhere, while local settings provide needs, users, constraints, or implementation sites. Under this model, situated experience may influence adaptation without altering the categories through which the problem was originally defined.

Discussions of pluriversality challenge this hierarchy by asking which forms of knowledge are recognized, whose interpretations influence decisions, and whether engagement changes the assumptions and methods of design. Smith et al. (2024) argue that decolonising design research requires more than broadening participation or adding geographically diverse cases. It requires attention to the positions from which knowledge is produced and to the ways research practices authorize or marginalize particular forms of knowing.

This does not mean that locally produced knowledge is automatically coherent, representative, or more valid than externally sourced expertise. Nor does it imply that imported technologies or specialized knowledge should be rejected. The relevant question is whether situated experience remains supplementary or acquires the capacity to transform the intervention.

Bhan and Tedjokusumo (2025) distinguish stakeholder mapping from knowledge mapping. Identifying who participates does not necessarily reveal which forms of knowledge shape the process. Participation becomes epistemically meaningful when it changes how the problem is represented, which criteria guide judgement, how responsibilities are distributed, or what remains open to validation.

This distinction limits the claims that can be made in the present study. Workshops, institutional collaboration, or local participation do not by themselves demonstrate epistemic equality, community ownership, or a fully decolonial process. Such claims require evidence that actors influenced the formulation and direction of the intervention in identifiable ways.

Epistemic responsibility therefore involves three commitments: making the researcher's position visible, distinguishing documented material from its interpretation, and limiting conclusions to what the evidence can support.

It also requires avoiding deficit representations of development contexts. Describing a setting mainly through missing infrastructure, limited capacity, or institutional weakness can obscure knowledge embodied in operational routines, repair practices, workshop experience, previous failures, institutional memory, and informal coordination. At the same time, these capabilities should not be romanticized or assumed to be unlimited.

A situated analysis must therefore examine which capabilities exist, how they operate, where their limits lie, and how they interact with external components, institutions, suppliers, and expertise. The aim is not to oppose local and external knowledge as homogeneous categories, but to make visible how knowledge, dependency, authority, and responsibility are distributed.

These considerations establish the analytical requirement followed in the case reconstruction: evidence must be connected to its source, interpretation, design consequence, and validation boundary.

2. RESEARCH DESIGN AND ANALYTICAL RECONSTRUCTION

A qualitative, practice-informed case approach was adopted to examine how operational conditions became epistemically active during the development of the O-Waste electric mobility component. Rather than evaluating the complete waste-management intervention or determining whether the emerging transport arrangement had already achieved operational success, the analysis reconstructs how situated evidence questioned assumptions, reformulated the mobility problem, and influenced criteria, responsibilities, and decisions.

O-Waste is treated as an illustrative case rather than as a representative model for infrastructure-constrained development contexts. Its analytical relevance lies in the visibility of an ongoing design process in which collection routes, load handling, vehicle configurations, suppliers, workshop capabilities, charging arrangements, monitoring procedures, and institutional responsibilities were still being defined.

2.1. Case boundaries and researcher position

The analytical corpus combines documentation produced during the second implementation year of O-Waste, from February 2025 to January 2026, with earlier experience involving electric tricycles in The Gambia. Earlier material was included only where it informed the interpretation of plausible operational risks. The principal reconstruction therefore rests on documented activities, decisions, and unresolved questions from the current project.

The author participated through an embedded role as industrial designer and technical consultant within the mobility component. Responsibilities included comparing vehicle alternatives, examining supplier information, interpreting route and load requirements, considering component and workshop arrangements, and contributing to possible mobility configurations.

Such proximity provided access to technical comparisons, project records, supplier exchanges, operational discussions, and changes of direction that would have been difficult to reconstruct externally. At the same time, it influenced which conditions were considered relevant and how their consequences were interpreted. No detached or neutral viewpoint is claimed; researcher positioning is treated as part of the knowledge-production process.

Knowledge did not emerge from the author's work alone. It developed through relations among Mbolo, KMC personnel, project managers, supervisors, collectors, market representatives, technical specialists, suppliers, workshop actors, and earlier vehicle experience. The analytical task was to identify where these heterogeneous sources and positions altered the understanding of the mobility problem.

The study is limited to the electric mobility component and to the conditions required for it to connect market collection with subsequent treatment. Composting performance, commercialisation, agricultural outcomes, and emissions remain outside the analysis except where they clarify the function of mobility within the wider circular process.

2.2. Evidence base

Materials used in the reconstruction were produced for implementation, technical development, planning, and institutional coordination. They were not originally created as a unified research dataset and therefore varied in purpose, detail, and evidential strength. Table 1 summarizes the main sources, their analytical function, and their principal limitations.

Table 1: Evidence base, analytical function, and limitations

Evidence source	Main actors or origin	Analytical function	Principal limitation
Project and operational records	Mbolo, KMC, project partners	Identify activities, delays, routes, procurement changes, protocols, and pending validation	Reflect institutional reporting priorities
Diagnostics, workshops, and meetings	KMC managers, supervisors, collectors, market personnel, external specialists	Examine how routes, roles, handling, monitoring, and organizational continuity influenced the problem	Not designed as standardized research interviews
Technical and supplier materials	Industrial designer, consultants, manufacturers, market platforms	Trace changes in criteria, configurations, components, maintenance, and procurement reasoning	Information was sometimes incomplete or inconsistent
Previous experience and external learning	Earlier Gambian tricycle activities, observations in Uganda, workshop preparation	Identify plausible risks and alternative support arrangements	Concerned different vehicles or contexts and could not be transferred directly

The core corpus comprised the Year 2 implementation report, route-diagnostic records for twelve pilot markets, materials from the June 2025 operational workshop, technical and supplier comparisons, workshop-preparation documents, and the author's earlier technical report on electric-tricycle trials. Together, these sources documented meetings with managers, supervisors, market staff, and collectors; supplier research; preparation of a local metalworking workshop; procurement of tools and components; and development of operational and monitoring procedures. Final assembly and field validation remained pending during the period examined.

No source was treated as independently conclusive. Project reports could establish that a concern, activity, or decision had been documented, but not prove that its interpretation was correct. Supplier specifications could support comparison without demonstrating future reliability. Workshops could reveal operational knowledge without establishing consensus or equal influence. Previous failures could identify plausible risks without proving that they would recur in the current project.

Four episodes were selected because each contained a traceable sequence linking a documented operational condition to a reformulation, a design consequence, and an explicit

Kaulicke, K., Cremades, L. V. (2026). From Operational Conditions to Design Knowledge: Situated Problem Reformulation in an Infrastructure-Constrained Development Context. *Strategic Design Research Journal. Volume 19*, number 01, January - June 2026. 36-53. DOI: 10.4013/sdrj.2026.191.04.

validation boundary. Selection was therefore analytical rather than comprehensive; the aim was to examine epistemic transformation, not to catalogue every project activity.

2.3. Analytical procedure, credibility, and ethical limits

The reconstruction followed five connected movements:

initial assumption → evidential friction → situated interpretation → design consequence → validation boundary

First, the analysis identified the assumptions through which the mobility task was initially represented, including range, payload, vehicle selection, procurement, and autonomy.

Second, project materials were examined for conditions that created friction with those assumptions. Particular attention was given to route operation, load handling, supplier dependency, workshop capability, charging, monitoring, maintenance, and institutional responsibility.

Third, each instance of friction was interpreted in relation to its source, purpose, and operational context. The analysis asked which category had become insufficient, which relation had been overlooked, and how the meaning of the problem changed.

Fourth, the reconstruction traced whether that interpretation produced a documented consequence. Evidence was treated as epistemically active only when it changed a criterion, redirected an alternative, modified an arrangement, redistributed responsibility, or expanded the design boundary.

Finally, documented consequences were separated from anticipated outcomes. Local assembly, modularity, smaller containers, additional traction, monitoring, or workshop preparation may constitute reasoned responses, but their operational value still requires field testing and longitudinal evidence.

Credibility was strengthened by comparing materials with different origins and purposes. The procedure remained interpretive rather than based on formal qualitative coding. Its aim was to establish traceability between assumption, friction, interpretation, consequence, and validation rather than statistical generalisation.

Several limitations remain. Embedded participation may introduce retrospective coherence by making an iterative process appear more orderly after reconstruction. Interviews and focus groups conducted for operational diagnosis were not designed as a standardized study, nor was individual testimony analysed as an independent dataset. Institutional records may also underrepresent disagreement, informal knowledge, abandoned alternatives, or unsuccessful exchanges.

Ethically, the analysis concentrates on project processes, institutional documentation, and technical decisions. No sensitive personal data are reported, and workshop participation is not treated as consent for individual attribution. Claims concerning participation, agency, or decolonial practice are therefore restricted to documented changes in criteria, responsibilities, arrangements, or decisions.

This procedure provides the basis for next Section, where the four episodes show how evidential friction contributed to reformulating electric mobility without confusing reasoned design consequences with demonstrated performance.

3. O-WASTE ELECTRIC MOBILITY AS AN OPERATIONAL CONNECTION

The present analysis does not address the complete O-Waste intervention. It focuses on the electric mobility component and on the operational conditions required for it to connect organic-waste collection at municipal markets with subsequent treatment. Within the wider circular process, mobility functions as an enabling link: if collection and transfer are interrupted, organic material does not reach the treatment facility and the intended circulation cannot continue.

Initially, the task could be represented as the selection of a lightweight electric vehicle with sufficient range, payload, power, dimensions, and cost. Project records, route diagnostics, workshops, supplier research, previous vehicle experience, and implementation planning gradually created friction with this formulation. The relevant problem was no longer simply which vehicle to acquire, but how electric mobility should be configured so that collection and transport could remain operable under situated conditions.

The following four episodes are organized through the same analytical logic: initial assumption, evidential friction, situated interpretation, design consequence, and validation boundary.

3.1. Mobility: from nominal route completion to controlled operation

The initial assumption was that mobility could be represented through the capacity to transport a required load over a defined distance. Range, motor power, speed, and nominal payload therefore appeared to provide an adequate basis for comparing alternatives.

Evidential friction emerged through route diagnostics conducted for twelve pilot markets. Using KMC's existing fuel-powered tricycles, the assessments documented differences in distance, road condition, market access, expected load, repeated stops, restricted circulation, and interaction with ongoing municipal activities. Workshops with managers, supervisors, collectors, and technical personnel further connected route planning with collection schedules and operational coordination (Mbolo Association, 2025).

Earlier experience with electric tricycles also challenged the initial representation. Battery-management difficulties, electrical exposure, traction limitations, stability concerns, and maintenance interruptions had shown that nominal specifications did not necessarily correspond to reliable use under local conditions (Kaulicke, 2021).

The situated interpretation was not simply that some routes were difficult. Rather, the evidence showed that route completion was an insufficient category for judging mobility. A vehicle could satisfy nominal requirements while remaining difficult to start, steer, brake, stabilize, or maintain during repeated collection cycles.

Mobility was therefore reformulated from *the capacity to complete a route* to *the capacity to sustain controlled and repeatable collection and transport under situated operating conditions*.

This interpretation produced a change in design criteria. Range and power remained relevant, but they could no longer be considered independently from manoeuvrability, traction, braking, load distribution, environmental exposure, and maintenance accessibility. Technical decisions were consequently treated as responses intended to preserve the operational connection between markets and treatment rather than as isolated specifications.

The validation boundary remains clear. Available evidence justifies changing the criteria through which mobility alternatives are compared, but it does not demonstrate successful long-term performance. Representative testing under actual routes, loads, stopping patterns, weather conditions, and operator routines is still required.

3.2. Payload: from numerical capacity to operational handling

The initial assumption was that payload could be treated as a maximum numerical quantity. This formulation facilitated comparison among vehicle alternatives, but it represented the load independently from the practices through which it would be collected, positioned, transported, emptied, and cleaned.

Evidential friction emerged from existing container practices and from the operational requirements associated with repeated waste collection. Project documentation identified 240-litre containers as standard units within the existing collection system. During the mobility analysis, 120-litre containers were considered as a more manageable option for vehicle-level transport. The issue was not container size alone, but how different configurations affected handling, loading, securing, weight distribution, operator effort, and cleaning.

The situated interpretation was that the same total quantity could produce substantially different operating conditions depending on how the material was divided and handled. Payload therefore could not be understood as an isolated number.

It was reformulated from *a maximum numerical capacity* to *an operational relation among material, container, operator, platform, and vehicle*.

This interpretation expanded the design boundary. Container dimensions influenced loading height, securing systems, partial loading, weight distribution, cleaning access, unloading, and transfer procedures. Tipping devices, cleaning equipment, weighing scales, and maintenance tools likewise became part of the mobility arrangement rather than supplementary equipment unrelated to transport.

The design consequence was not the definitive selection of a particular container. It was the incorporation of handling into the criteria through which the cargo system was configured. Electric mobility was understood as supporting a repeated sequence of collection, loading, transport, unloading, cleaning, and renewed use rather than moving an abstract quantity between two points.

The validation boundary remains unresolved. The 120-litre option represents a reasoned response to handling concerns, not a validated solution. Operator trials, loading sequences, securing procedures, cleaning requirements, and vehicle behaviour under partial or uneven loads still require field testing.

3.3. Procurement: from product acquisition to distributed dependency

The initial assumption was that procurement concerned the acquisition of a complete electric cargo vehicle. Purchase price, technical specifications, delivery time, and apparent compatibility with the collection task would therefore constitute the principal considerations.

Evidential friction emerged through supplier research, procurement delays, and previous maintenance experience. Supplier information was frequently incomplete, technical transparency varied, communication with manufacturers proved difficult, and access to replacement batteries, motors, controllers, braking components, and compatible interfaces could not always be assumed. Project materials also exposed uncertainty regarding after-sales support, component availability, and workshop capacity (Mbolo Association, 2025).

Further friction arose from observations of e-mobility practices in Uganda. Vehicle continuity depended not only on acquisition, but also on assembly, maintenance arrangements, spare parts, after-sales support, and the possibility of repairing, replacing, or adapting components. These observations challenged the assumption that a technically suitable product could be evaluated independently from the support relations required after purchase.

The situated interpretation was that procurement distributed dependency. Every choice concerning suppliers, components, interfaces, documentation, and repair arrangements also determined where technical control and vulnerability would be located.

Procurement was therefore reformulated from *purchasing a suitable product* to *distributing technical dependency across suppliers, components, workshops, documentation, and responsibilities*.

This interpretation produced several design consequences. Fully assembled imports were no longer the only relevant option. Existing vehicles, differentiated components, local workshop activity, external supply, replacement planning, and accessible interfaces became part of the emerging arrangement. A local metalworking workshop could potentially support structural modification, assembly, inspection, and selected repairs, while batteries, motors, controllers, and safety-critical systems would continue to depend partly on external suppliers and specialized expertise.

This distinction prevents an exaggerated claim of local self-sufficiency. Fabrication, assembly, diagnosis, repair, replacement, adaptation, and specialized servicing are separate capabilities. The strategic objective is not to eliminate external relations, but to reduce critical dependency and avoid concentrating all maintenance knowledge, component access, and repair authority outside the operating context.

The validation boundary concerns sustained performance. The effectiveness of this arrangement can only be assessed through maintenance histories, spare-part access, replacement times, workshop performance, and the continuity of operation after implementation.

3.4. Autonomy: from battery range to organizational continuity

The initial assumption was that autonomy could be represented primarily through battery capacity and expected range. If a vehicle could complete an estimated route on one charge, it could appear operationally independent.

Evidential friction emerged as planning connected battery range with charging routines, scheduling, route management, reporting, maintenance, monitoring, and institutional responsibility. A participatory diagnosis involving KMC managers, supervisors, and collectors was followed by an operational design workshop in June 2025. These activities informed route organization, roles, Terms of Reference, reporting procedures, and monitoring arrangements covering weights, contamination, incidents, vehicle use, and daily operation. GPS and mobile applications were also considered as possible means of tracking routes and maintenance needs (Mbolo Association, 2025).

The situated interpretation was that technical range alone could not ensure continuity. A vehicle might possess sufficient battery capacity but still fail operationally if charging responsibilities were unclear, faults were not reported, maintenance was delayed, or data were unavailable for revising procedures.

Autonomy was therefore reformulated from *the technical independence of a vehicle* to *the coordinated capacity of an organization to sustain, monitor, repair, and revise the mobility service*.

This interpretation produced an organizational design consequence. Charging, route management, incident reporting, maintenance, monitoring, and data collection became interconnected responsibilities rather than secondary administrative tasks. Monitoring acquired epistemic relevance because route records, load data, battery condition, maintenance events, and operator observations would generate the future evidence needed to test current assumptions.

Participation also requires careful interpretation. The involvement of KMC personnel, supervisors, collectors, market representatives, Mbolo, workshop actors, suppliers, and external specialists did not automatically demonstrate equal influence. Their knowledge became consequential where diagnoses, workshops, and exchanges produced identifiable changes in routes, responsibilities, monitoring procedures, or maintenance arrangements.

The validation boundary is longitudinal. Charging reliability, adherence to procedures, maintenance response, data quality, institutional coordination, and the capacity to adapt the service must be examined once routine operation begins.

3.5. Cross-domain synthesis

The four episodes reveal a common movement from a vehicle-centred task toward the configuration of an operational mobility arrangement. Figure 1 synthesizes this transformation by connecting the initial framing, situated operational evidence, epistemic reformulation, resulting design orientation, and the continuing cycle of validation and learning.

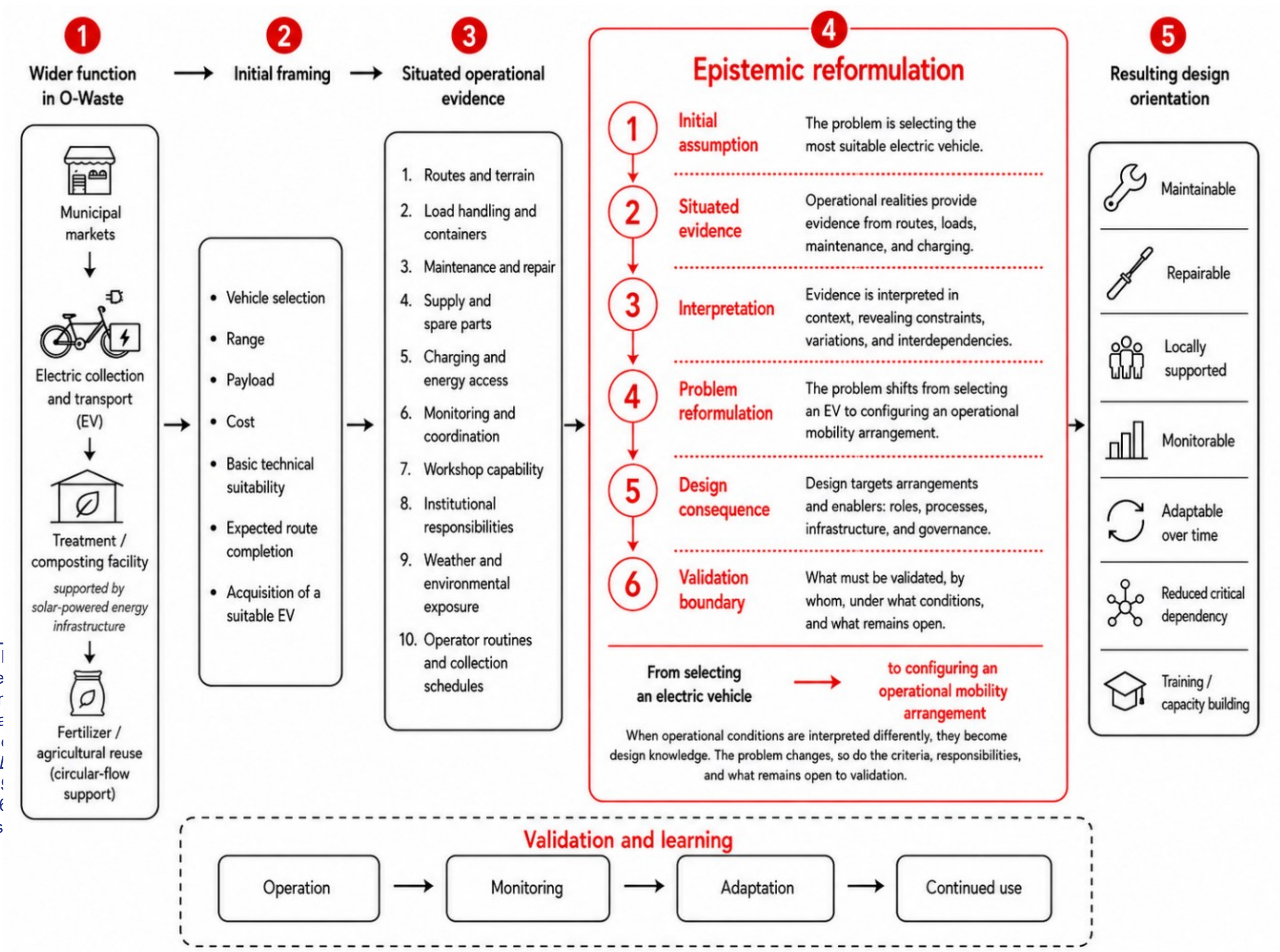

Figure 1. Situated epistemic reformulation of the O-Waste electric mobility component.

Kaulicke, I
From Ope
Design Kr
Reformula
Constrain
Strategic I
Volume 1!
June 202(
10.4013/s

Table 2 translates this overall transformation into the four analytical domains examined in the section. It shows how each initial assumption encountered evidential friction, how that friction was interpreted, which mobility concern was reformulated, and what remained open to validation.

Table 2: Cross-domain synthesis of electric mobility reformulation

Initial framing	Situated evidence	Reformulated mobility concern	Role in operational continuity	Validation boundary
Select a vehicle with adequate range and payload	Route diagnostics, previous vehicle experience, and operational workshops	Configure reliable collection and transport under actual operating conditions	Maintains the connection between municipal markets and the treatment facility	Testing under representative routes, loads, stopping patterns, weather, and operator routines
Treat payload as a numerical capacity	Container practices, handling requirements, loading, cleaning, and transfer procedures	Integrate material handling into the mobility arrangement	Enables repeated collection, loading, transport, unloading, cleaning, and renewed use	Operator trials, securing procedures, cleaning, and partial or uneven load testing
Acquire a complete electric vehicle	Supplier uncertainty, procurement delays, maintenance experience, and workshop capability	Distribute technical dependency across components, suppliers, documentation, workshops, and responsibilities	Reduces the risk that component failure or unavailable support interrupts the mobility service	Maintenance histories, replacement times, spare-part access, and workshop performance
Define autonomy through battery range	Charging arrangements, route management, monitoring, reporting, maintenance, and institutional coordination	Organize continuity through energy, information, maintenance, and assigned responsibilities	Supports sustained operation, monitoring, repair, and adaptation over time	Longitudinal evidence on charging reliability, maintenance response, coordination, and learning

Taken together, the episodes show that the mobility component was not reformulated into the complete 0-Waste system, nor into a claim of technical self-sufficiency. Its scope remained specific: to sustain collection and transfer between markets and treatment. The broader epistemic consequence was that electric mobility could no longer be understood as an isolated product. It became an arrangement linking vehicle configuration, material handling, charging, maintenance, suppliers, workshop capability, institutional responsibility, and operational learning.

The relevant result is therefore not a final vehicle architecture, but a traceable change in the problem itself. Operational conditions became design knowledge when they created friction with initial assumptions, were interpreted in relation to the project, and produced identifiable consequences for criteria, responsibilities, and validation.

4. DISCUSSION

The findings clarify a distinction between making systemic relations visible and showing how those relations transform design reasoning. Systemic design, infrastructuring, and situated design research have already established that artefacts depend on wider material, institutional, and operational arrangements. The contribution developed here concerns how those arrangements become consequential when they create friction with an initial assumption and are interpreted into changes in problem formulation, design criteria, responsibility, or validation.

In the case examined, electric mobility was not simply expanded from a vehicle into a broader system. Situated evidence challenged the adequacy of vehicle selection as the central task and reformulated the problem as the configuration of an operational arrangement capable of sustaining collection and transport within the wider O-Waste process.

4.1. From system recognition to epistemic reformulation

Systemic approaches reveal interdependencies among artefacts, infrastructures, organizations, practices, and actors. Such recognition is essential where technical viability depends on conditions extending beyond the physical product. Yet identifying a relationship does not necessarily explain when or how it changes design reasoning.

This article distinguishes *system recognition* from *epistemic reformulation*. System recognition makes dependencies visible. Epistemic reformulation occurs when one of those dependencies creates evidential friction with the initial framing and its interpretation changes how the problem is defined, introduces or modifies a criterion, redirects a decision, redistributes responsibility, or establishes a boundary for validation.

A route map, supplier network, institutional diagram, or workshop description may therefore remain contextual. It becomes analytically significant only when its interpretation changes how the intervention proceeds. Route conditions became consequential because they made nominal route completion insufficient as a definition of mobility. Handling practices challenged the representation of payload as a numerical capacity. Supplier uncertainty transformed procurement into a problem of distributed dependency. Monitoring entered the design boundary because it became necessary for testing assumptions and revising operation. This distinction refines the relationship between systemic analysis and industrial design action. Moving beyond the isolated artefact becomes useful when system-level relations can be traced into material, operational, or organizational consequences. System awareness does not replace technical design; it changes the grounds on which technical decisions become justifiable.

Situated knowledge is therefore not defined merely by geographical location or by the participation of local actors. Its significance emerges through relations among actors, experiences, materials, infrastructures, interpretations, and decisions. A condition becomes epistemically active when its interpretation reveals the insufficiency of an existing formulation and produces an identifiable consequence.

4.2. Strategic design as the distribution of capability and dependency

Strategic implications emerge from the way reformulated design problems redistribute knowledge, responsibility, capability, and dependency over time.

Procurement offers the clearest example. A complete imported vehicle may simplify initial acquisition while concentrating component access, maintenance knowledge, and repair authority outside the operating context. Local assembly may increase accessibility and adaptability, but it also introduces demands for coordination, documentation, quality control, and specialized support. The relevant strategic question is therefore not whether the mobility arrangement should be local or imported, but how different capabilities and dependencies should be distributed.

Within the emerging hybrid approach, assembly, structural modification, inspection, replacement, and selected repairs could potentially be supported closer to the project, while batteries, motors, controllers, and safety-critical systems would remain dependent on external suppliers and specialized knowledge. This distinction influenced component selection, workshop preparation, interface accessibility, tooling, documentation, and replacement planning.

Such decisions extend beyond immediate technical performance. They determine who can diagnose a failure, authorize or conduct a repair, obtain a replacement, adapt the system after implementation, and retain technical knowledge once external support decreases.

Protocols and monitoring distribute responsibility in a comparable way. Charging, route management, incident reporting, maintenance, and data collection connect operators, supervisors, institutions, workshops, and suppliers. Their organization affects whether the mobility service can continue, generate evidence, and adapt over time.

Strategic design can therefore be understood here as the deliberate configuration of material and institutional relations that shape continuity. The design object includes not only the vehicle architecture, but also the capabilities required to operate, inspect, repair, revise, and sustain the mobility service.

This interpretation also gives practical substance to the decolonial concern without overstating the case. The project does not demonstrate complete epistemic equality, technological autonomy, or independence from external systems. It does show how situated evidence challenged a one-directional transfer model by making local maintenance, operational knowledge, workshop capacity, and adaptation consequential to design.

The relevant result is therefore not self-sufficiency, but a partial redistribution of technical agency and a reduction of critical dependency. External components and expertise remain necessary, but the mobility arrangement is less likely to depend entirely on actors located outside the operating context.

4.3. Epistemic responsibility, transferability, and limitations

Practice-informed knowledge remains partial. Project reports, consultancy work, operational diagnoses, workshops, supplier exchanges, and institutional records were produced for different purposes and from different positions. Their interpretation cannot be separated from those conditions.

The researcher's embedded role provided access to decisions, tensions, and changes of direction, but it also shaped the reconstruction. Retrospective analysis may make an iterative process appear more coherent than it was. Likewise, participation by local actors cannot be treated automatically as evidence of equal influence. Claims are therefore limited to instances where available documentation shows that particular forms of knowledge changed criteria, responsibilities, arrangements, or decisions.

Validation presents a second limitation. The study demonstrates reformulation, not final operational success. Available evidence supports the claim that operational conditions altered mobility criteria, integrated handling into the design boundary, redirected procurement, and expanded autonomy to include organizational continuity. It cannot yet establish long-term reliability, reduced downtime, successful maintenance, institutional continuity, or operator acceptance.

Traceability and validation must therefore remain distinct. Traceability reconstructs how an initial assumption encountered evidential friction, how that friction was interpreted, and which consequence followed. Operational validation determines whether the resulting arrangement performs as expected under sustained use.

Direct transfer of the resulting mobility configuration would also be inappropriate. Other contexts will involve different routes, infrastructures, actors, suppliers, capabilities, institutional arrangements, and material flows. What may be transferable is the analytical orientation:

identify the initial assumption, locate the evidence that challenges it, interpret what has become insufficient, trace the resulting design consequence, and preserve the boundary between current reasoning and future validation.

The case therefore contributes neither a universal electric mobility model nor a fixed method. Its value lies in showing how situated operational evidence can become epistemically active and strategically consequential through a traceable interpretation of the problem itself.

5. CONCLUSION

Situated operational evidence becomes epistemically significant when it creates friction with an initial assumption and its interpretation reformulates the design problem, modifies criteria, redirects responsibility, or establishes what still requires validation.

Recognizing actors, infrastructures, materials, and dependencies may broaden the representation of a system, but recognition alone does not produce design knowledge. Such relations become consequential only when they reveal the insufficiency of an existing formulation and alter how decisions are justified. In the case examined, electric mobility was reformulated from vehicle selection into an operational arrangement capable of sustaining collection and transport within the wider O-Waste process.

A designer can therefore justify problem reformulation by demonstrating a traceable sequence between an initial assumption, the situated evidence that challenges it, the interpretation of why that assumption becomes insufficient, the resulting design consequence, and the remaining validation boundary. This preserves the distinction between reasoned decisions and claims requiring operational testing.

A further conclusion concerns strategic design. Strategy is embedded in decisions that distribute capability, dependency, knowledge, responsibility, and authority across technologies, institutions, suppliers, workshops, and operators. These distributions shape whether the mobility service can be operated, repaired, adapted, and sustained over time. The objective is not complete self-sufficiency, but reduced critical dependency and greater capacity for local operation, maintenance, and learning.

This sequence should not be treated as a universal method. Its contribution is epistemological: it provides a way to examine how operational experience becomes knowledge capable of changing the problem itself.

REFERENCES

Abdulla, D., Ansari, A., Canlı, E., Keshavarz, M., Kiem, M., Oliveira, P., Prado de O. Martins, L., & Schultz, T. (2019). A manifesto for decolonising design. *Journal of Futures Studies, 23*(3), 129–132. https://doi.org/10.6531/JFS.201903_23(3).0012

Bhan, N., & Tedjokusumo, L. Z. (2025). Knowledge mapping: User research for plural, just, and equitable co-creation interface design. *International Journal of Design, 19*(3), 83–99. https://doi.org/10.57698/v19i3.04

Hornbuckle, R., Page, R., & Nogueira, A. (2024). How do we articulate design research to other academic disciplines? In C. M. Gray, P. Hekkert, L. Forlano, & P. Ciuccarelli (Eds.), *DRS2024: Boston*. Design Research Society. https://doi.org/10.21606/drs.2024.1572

Irwin, T., Tonkinwise, C., & Kossoff, G. (2020). Transition design: An educational framework for advancing the study and design of sustainable transitions. *Cuadernos del Centro de Estudios de Diseño y Comunicación*, (105), 31–65. https://doi.org/10.18682/cdc.vi105.4188

Kaszynska, P., & Kimbell, L. (2025). Design practice research: Conditions and outcomes. *Design and Culture, 17*(1), 49–70. https://doi.org/10.1080/17547075.2024.2401240

Kaulicke, K. (2021). *Report on the tests carried out with tricycles of the Fandema Project in The Gambia* [Technical report]. Mbolo Association.

Klein, A., Unverzagt, K., Alba, R., Donges, J. F., Hertz, T., Krueger, T., Lindkvist, E., Martin, R., Niewöhner, J., Prawitz, H., Schlüter, M., Schwarz, L., & Wijermans, N. (2024). From situated knowledges to situated modelling: A relational framework for simulation modelling. *Ecosystems and People, 20*(1), Article 2361706. https://doi.org/10.1080/26395916.2024.2361706

Mbolo Association. (2025). *Re-circulating 0-Waste in The Gambia's food supply chain: Year 2 implementation report* [Internal project report].

Schultz, T., Abdulla, D., Ansari, A., Canlı, E., Keshavarz, M., Kiem, M., Prado de O. Martins, L., & Vieira de Oliveira, P. J. S. (2018). What is at stake with decolonizing design? A roundtable. *Design and Culture, 10*(1), 81–101. https://doi.org/10.1080/17547075.2018.1434368

Sevaldson, B. (2013). Systems oriented design: The emergence and development of a designerly approach to address complexity. In J. B. Reitan, P. Lloyd, E. Bohemia, L. M. Nielsen, I. Digranes, & E. Lutnæs (Eds.), *DRS // Cumulus: Design learning for tomorrow*. Design Research Society. https://doi.org/10.21606/learnxdesign.2013.133

Smith, R. C., Winschiers-Theophilus, H., Abreu de Paula, R., Zaman, T., & Loi, D. (2024). Towards pluriversality: Decolonising design research and practices. *CoDesign, 20*(1), 1–13. https://doi.org/10.1080/15710882.2024.2379704

van der Bijl-Brouwer, M., Celik, S., de Koning, J., Nieuwborg, A., & Tromp, N. (2024). Systemic design reasoning for societal transitions. In C. M. Gray, E. Ciliotta Chehade, P. Hekkert, L. Forlano, P. Ciuccarelli, & P. Lloyd (Eds.), *DRS2024: Boston*. Design Research Society. https://doi.org/10.21606/drs.2024.585

Kaulicke, K., Cremades, L. V. (2026). From Operational Conditions to Design Knowledge: Situated Problem Reformulation in an Infrastructure-Constrained Development Context. *Strategic Design Research Journal. Volume 19*, number 01, January - June 2026. 36-53. DOI: 10.4013/sdrj.2026.191.04.