

Negative Results and Failed Replication in Photopolymer Research: Reporting, Censoring and Engineering Value

Reframing failed prints, null effects and non-replication as boundary evidence that can prevent repeated dead ends and unsafe extrapolation

Juan Seguro

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Correspondence: info@3Dresyns.com · www.3Dresyns.com

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Abstract

Negative results are routinely lost through publication bias, selective reporting and informal laboratory filtering. In photopolymer engineering this loss is costly because failed prints, absent property gains and failed replications often define process boundaries more directly than successful demonstrations. This review distinguishes informative negative evidence from uninformative failure, identifies common censoring mechanisms, and proposes a reporting structure for failed replication and null results. The objective is not to publish every unsuccessful trial, but to preserve failures that constrain an engineering claim or reveal hidden state dependence.

Keywords: negative results; failed replication; publication bias; photopolymer; reproducibility; failed print; null result

1. Positive-outcome bias distorts the apparent feasible region

The file-drawer problem describes the loss of non-significant or negative studies from the visible literature [1]. Fanelli documented a broad decline in published negative results across disciplines [2]. In photopolymer AM, a similar selection mechanism can occur before publication: only printable formulations, intact specimens or successful parameter sets reach the reported dataset. The visible literature can therefore overestimate robustness.

2. A failed print can be evidence if the state is known

Failure is informative when the input state, attempted process and failure criterion are sufficiently specified. A delaminated part after a known exposure window constrains process feasibility; a statement that a resin did not print without machine, layer, exposure or failure description does not. Negative evidence needs the same minimum-information discipline as successful data.

Table 1. Negative-evidence classes.

Class	Example	Engineering value
null effect	additive does not change modulus within sensitivity	rules out lever in tested state
process failure	no stable print in tested window	defines infeasible region
failed replication	reported gain not reproduced	tests transferability
adverse trade-off	gain in strength with unacceptable brittleness	constrains optimisation
censored outcome	specimens excluded after breakage	reveals denominator risk

3. Failed replication has several meanings

A replication can fail because the original effect was unstable, because the replication did not reproduce the original state, because an undocumented variable mattered, or because measurement noise dominated. Large replication initiatives in other fields show that reproducibility is not guaranteed even when original studies are statistically persuasive [3]. Engineering interpretation therefore begins with a state and protocol reconciliation rather than a binary replicated/not-replicated label.

4. Censoring occurs at multiple gates

Censoring can happen when failed formulations are excluded from analysis, when specimens that break during handling are removed, when outliers are discarded without rule, when parameter sweeps report only the best window, or when unsuccessful replication attempts remain internal. Each gate changes the denominator. A credible study should state how many planned, attempted, completed and analysed specimens or parameter conditions existed.

Table 2. Minimum failed-replication record.

Field	Required content
target	claim and source being replicated
matched state	variables reproduced
unmatched state	known deviations or unknowns
attempt census	planned, attempted, completed, analysed
outcome	effect estimate or failure criterion with uncertainty

5. Negative results can have positive decision value

A null effect can rule out a hypothesised lever; a failed replication can prevent transfer; a failure map can identify safe boundaries. These outcomes reduce uncertainty even when they do not improve a headline property. The engineering value is strongest when the negative result changes the next decision.

6. Reporting should separate absence of effect from absence of evidence

A study with insufficient sensitivity cannot establish that an effect is absent. Reports should therefore provide detection limits, uncertainty or power logic appropriate to the endpoint. Ioannidis emphasised the role of design and bias in the credibility of research findings [4]. In photopolymer work, a negative claim should be no broader than the tested state and detectable effect size.

Table 3. Publication-bias controls for engineering datasets.

Control	Purpose
predefined exclusion rules	prevent post hoc removal
full parameter-window map	show failed as well as successful regions
denominator reporting	expose attrition
failure taxonomy	separate process, specimen and measurement failures
repository for null results	make boundary evidence discoverable

7. Replication records should be reusable

A failed replication record should include the original target claim, matched and unmatched state variables, protocol deviations, outcome, uncertainty and proposed discriminating test. This turns failure into structured input for later evidence synthesis.

8. Scope boundary and neighbouring reviews

ER-397 owns negative results, failed replication and the conditions under which non-confirmation has engineering value. ER-396 owns broader conflict resolution between competing evidence states, and ER-398 owns dataset coverage, leakage, shift and fitness for modelling. ER-397 therefore governs negative evidence, not benchmark-dataset qualification.

9. Failure records need a taxonomy, not a free-text note

A negative result is reusable only when the failure mode is classified. For photopolymer work, useful categories include non-printability, incomplete cure, overcure or feature merging, delamination, support failure, trapped liquid, wash damage, post-cure distortion, brittle fracture, environmental degradation, measurement failure and failure to meet the engineering acceptance criterion despite successful fabrication. These categories separate process failures from material-property failures and from test-system failures. A free-text statement such as 'printing failed' loses that distinction and cannot define the boundary of the feasible region.

10. The denominator is part of the evidence

Selective reporting hides how often an outcome was attempted. A dataset that contains five successful parameter combinations is difficult to interpret if fifty unsuccessful combinations were omitted. ER-397 therefore treats the attempted-condition denominator as a required field whenever feasibility or robustness is inferred. At minimum, the record should state the candidate space considered, the number of attempted conditions, the exclusion logic and whether failures were censored before measurement. Publication-bias literature shows why preferential visibility of positive findings distorts the apparent evidence base [1,2]. In process development the same mechanism can make a narrow operating window look broad.

11. Failed replication should distinguish protocol identity from conceptual identity

Replication failure is not one category. A direct replication attempts to reproduce the same protocol and state; a close replication changes only controlled nuisance factors; a conceptual replication tests the same proposed mechanism through another implementation. These forms answer different questions. A direct failure may indicate undocumented process state or measurement problems, while a conceptual failure may indicate that the mechanism is not transportable. The record should therefore identify which elements were held invariant and which were intentionally changed before the result is labelled non-replication.

12. Prospective registration can protect informative null results

Registered Reports were developed to align publication decisions with the importance and rigour of the research question before results are known [5]. The exact publishing model need not be imported wholesale into engineering R&D, but the principle is useful: predeclare the primary endpoint, analysis rule and acceptance boundary before observing the outcome. Internal qualification programmes can implement the same protection through signed test plans. This reduces the temptation to relabel an inconvenient null result as 'exploratory' or to move the success criterion after the experiment.

13. Reusable negative-result package

A reusable failure package should include material and batch identity, machine and software state, parameter set, specimen geometry, environmental conditions, observed failure mode, raw or minimally processed measurements, images where relevant, and the decision rule that classified the outcome as negative. It should also record whether the failure was repeated and whether a nearby successful condition exists. Such a package has direct engineering value: it can exclude unsafe or unproductive regions, train robust models, prevent duplicated work and identify which variable should be changed next. Negative evidence becomes valuable when it constrains the feasible region with the same traceability expected from positive evidence.

14. Censoring can occur before, during and after measurement

Failure evidence can disappear at several stages. Candidate formulations may be dropped before printing; failed builds may not be logged; damaged specimens may be excluded before testing; outlying measurements may be removed after testing; and completed null studies may remain unpublished. Each stage creates a different missing-data mechanism. The record should therefore identify the last observed state for every attempted condition and whether the reason for absence is known. This prevents a dataset of measured survivors from being mistaken for the full experimental population.

15. Escalation after a failed replication

A failed replication should trigger a structured escalation, not an immediate accusation of irreproducibility. First verify identity and protocol completeness. Second test high-sensitivity state variables such as cure history, temperature, humidity or machine calibration. Third perform a crossed experiment if feasible, exchanging material or specimens between laboratories. Fourth reassess whether the original claim was narrower than assumed. Only after these steps should the corpus label the finding as unresolved or non-reproducible. The escalation record itself becomes reusable evidence about which hidden variables matter.

16. Engineering value of negative evidence

Negative evidence can reduce search space, improve safety margins and expose brittle process windows. A series of failed prints at low exposure can define a lower feasibility boundary; failures after ageing can identify a service-state limit; a null effect across a well-powered study can prevent investment in an ineffective additive. The value depends on traceability and denominator, not on whether the outcome is positive. This is why ER-397 treats failure records as first-class data products rather than informal laboratory notes.

17. Minimum failed-attempt record

A failed attempt should preserve enough information to be interpretable later. The minimum record includes intended condition, material and batch identity, machine and process state, specimen or build identifier, stage of failure, observable failure mode, any measured response, operator intervention, and whether the attempt consumed a planned replicate. A reason code should distinguish process infeasibility, equipment fault, protocol deviation, specimen damage and unexplained failure. Free text remains useful, but a controlled failure taxonomy is needed for aggregation. This record allows future users to calculate denominators and identify recurrent failure modes rather than seeing only the successful survivors.

18. Statistical consequences of selective survival

If only successful prints or intact specimens reach the final analysis, the reported performance distribution is conditional on survival. That conditioning can bias means, underestimate variance and create a false impression of a wide process window. The analysis should therefore report attrition by stage and, where appropriate, analyse feasibility and conditional performance as separate outcomes. A material that produces excellent tensile properties in 60% of builds is not equivalent to one with slightly lower strength but 99% build success. Engineering qualification should preserve both dimensions because yield and robustness affect decision value even when the scientific endpoint is unchanged. [1,2,4]

19. Closing a replication discrepancy

A replication discrepancy should be closed with one of several explicit dispositions: reproduced after hidden-variable correction; not reproduced under matched conditions; original claim narrowed; protocol incompletely specified; measurement disagreement unresolved; or replication invalid because a critical condition could not be matched. The disposition should cite the evidence and retain both original and replication records. This approach avoids binary labels such as 'replicated' and 'failed' when the actual lesson is that the original claim depended on an unreported material or process state. The closure then improves the corpus rather than merely assigning blame.

20. Denominator-aware process maps

For additive manufacturing, the denominator should follow the complete process funnel: formulations attempted, vats prepared, builds started, builds completed, parts recovered, parts passing visual inspection, specimens machined or prepared, specimens tested and results included in the final analysis. Attrition at each gate can have a different cause. Reporting only the last denominator hides whether a material is scientifically weak, operationally fragile or simply affected by an equipment incident. A process map with counts and reason codes converts failures into evidence about manufacturability and robustness.

21. Negative results and safety margins

Negative evidence is especially valuable near safety or qualification boundaries. A failed pressure test, sterilisation cycle or ageing exposure can define a no-go region even if the exact failure mechanism is not yet known. Such results should be preserved with the same state variables and uncertainty controls as successful tests. Repeating only successful conditions narrows the observed dataset around the feasible region and can produce unsafe extrapolation. ER-397 therefore treats well-characterised failures as boundary measurements that can constrain design before a full mechanistic model exists.

22. Publication and repository practice

A reusable negative-result record should be citable independently or bundled with the associated positive study, with stable identifiers and sufficient metadata for discovery. The abstract or metadata should state the attempted condition and outcome rather than using vague labels such as 'unsuccessful'. Where commercial confidentiality prevents disclosure of formulation details, bounded descriptors and process-state metadata can still preserve engineering value. The aim is to prevent failed work from disappearing while respecting legitimate disclosure limits. [2,5]

23. Limitations and research priorities

The principal limitation is that negative and failed outcomes are systematically harder to discover than successful studies, so the literature cannot reveal the true denominator without prospective recording. Priorities are denominator-aware build logs, shared failure taxonomies, repositories for failed qualification attempts, and replication studies that exchange materials or specimens between laboratories. Statistical

methods should explicitly model attrition where only surviving specimens reach the endpoint. Cultural incentives also matter: a negative-result infrastructure will fail if records are treated as evidence of poor laboratory performance rather than information about process boundaries. ER-397 therefore frames failed work as a controlled engineering asset only when identity, protocol, stage of failure and denominator are preserved. [1-5]

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Competing interests

The author is Founder, CEO and CTO of 3Dresyns by Resyner Technologies S.L.; ER-397 is a methodological engineering review and does not provide a comparative commercial recommendation.

Data availability

ER-397 is a literature-based engineering review; no new experimental dataset was generated.