

Moral Dimensions of Substrate Research Programmes

2025's [Substrates Workshop](#) garnered a wide spectrum of approaches to this nascent field of software construction. As the [call for this year's workshop](#) acknowledged, these could be fitted onto one or more dimensions, reflecting different modes of enquiry and the interests of different research communities. Articulating these dimensions and trying to place the work of our contributors along them might help clarify the relationships between the work of different groups and how they can complement each other, and how they could be scheduled as part of the work of a larger research programme.

This short paper makes some highly provisional attempts to identify such axes and place some relevant work on them. It should be considered as a spring-board for discussion and mutual illumination rather than a finished taxonomy.

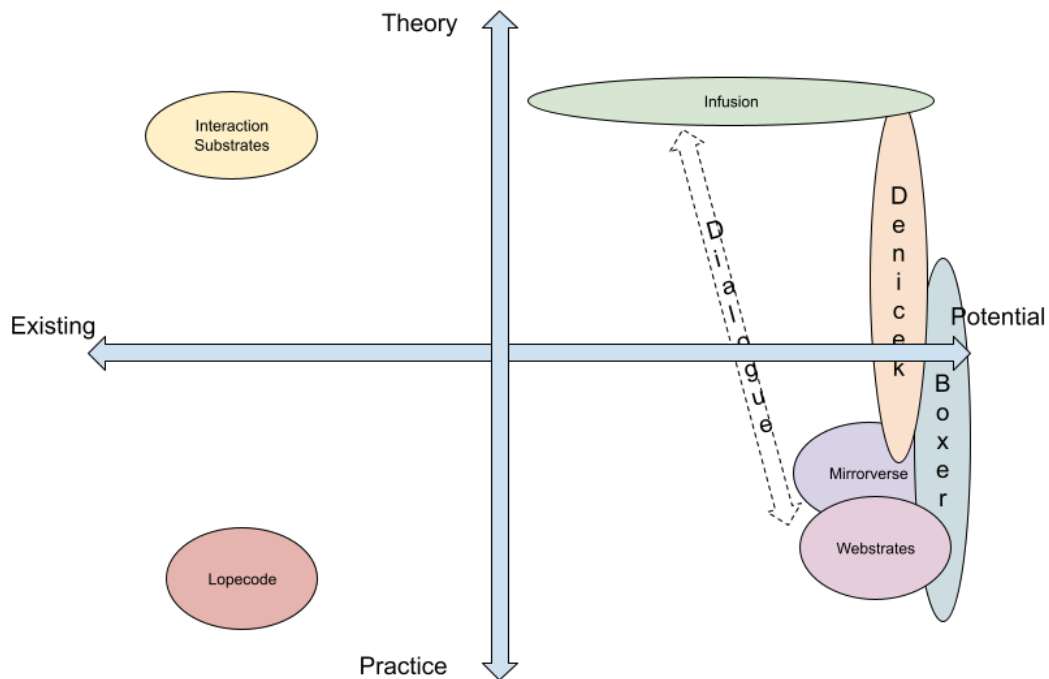
Firstly, there is the familiar axis of orientation between theory-based and practice-based approaches. This resembles the split identified in Richard Gabriel's 2012 [Structure of a Programming Language Revolution](#) between those operated by "systems-based" and "language-based" programming, identifying a point in the late 1980s where these two communities ceased to be in contact with each other. Gabriel remarks, "Engineers build things; scientists describe reality; philosophers get lost in broad daylight". Gabriel notes that, as with successful development of mechanisms such as steam engines whilst theory was still preoccupied with chimerae such as phlogiston, engineering efforts can precede and support theoretical ones, whereas under some stereotypes, theory precedes practice.

Secondly, there is the related but distinct axis of being oriented to past or future artefacts - one may either be reading "substrate nature" into artefacts already produced, or else considering what novel substrates could be constructed in future.

For example, the [Interaction Substrates](#) of Mackay and Beaudoin-Lafon (2025) views existing artefacts through a theoretical lens, positioning it at the top left of this notional space.

An interesting example of a practice/theory dialectic can be seen between [Between Principle and Pragmatism](#) (Borowski et al, 2022), [Substrates: From Webstrates and Beyond](#) (Klokmoose, 2025), and Basman's responses to the latter's 6 substrates principles in the reviews below it. This shows that Webstrates can be positioned at the bottom right of the diagram, as being a future-oriented practice-based framework, in dialogue with the Infusion system which provides a theoretical lens with which to analyse the substrates principles, and explain how software systems can be built which remedy them.

It's important to distinguish that the Theory/Practice axis is intended to be interpreted with respect to ordinary citizens experiencing the substrate artefacts. Whilst Infusion is a concrete software system, it currently exposes little in the way of an instrumental interface which could be used to refine its interaction idiom. Webstrates on the other hand is a practice-oriented framework which puts fresh interactions and their possibilities in an experimental domain. And whilst Webstrates is also a concretely existing software system, it was freshly constructed as part of a substrates research programme and informed by it, and hence counts as a "Potential" rather than "Existing" system.



[Denicek](#) (Petricek and Edwards, 2025) is an example of a system which straddles the theory-practice divide. As well as proposing a novel underpinning for substrates based on an edit calculus, it also exhibits novel user-level interactions arising from that underpinning.

Different systems don't occupy simple points in this space but rather correspond to an extended cloud of orientations, which we try to represent through extending the ellipse dimensions. For example, Infusion whilst a novel, substrate-oriented development extends towards the "existing" left axis since it attempts to resituate and redeem existing programming idioms such as reactive programming and RESTful architectures.

[Lopecode](#) (Larkworthy, 2025) occupies the lower left quadrant since it is built on an already established underpinning, the Observable notebook system, and examines the interactional possibilities available through exporting this system as a more available substrate.

The area even further down to the left is occupied by systems such as Hypercard and even Excel. These are often touted in our community as software or programming systems with substrates-like qualities where we theorise about how these emerge.

Substrates-related research can be characterised as contributing *episteme*¹ (how to conceptualise substrates), *techne* (how to actually build them), and *phronesis* (when, why, and how substrates make sense in practice). The latter can be experientially driven by constructing and engaging with possible alternative futures.

¹ These words are taken from Aristotle's "Five Virtues of Thought" from his Nicomachean Ethics ~350BC. In full these virtues are

1. Artistry or craftsmanship (Greek: *techne*)
2. Prudence or practical wisdom (*phronesis*)
3. Intuition or understanding (*nous*)
4. Scientific knowledge (*episteme*)
5. Philosophic wisdom (*sophia*)

What questions can we ask about how research is done, either overall, or about the relationship between how work is done in different quadrants? There isn't a clear time relationship as Richard Gabriel points out - theory can't precede practice, nor vice versa.

Can we also distinguish between different kinds of theory? Perhaps in terms of "explanatory theory" and "actuating theory"? The former explains the behaviour of an existing system against a theoretical background. The latter explains why a system has been designed to choose a particular operation, or perform a particular action] at the pursuit of some goal. E.g. stack frames were a particular construct built via a particular actuating theory, reactive networks are another.

In [Generative Theories of Interaction](#) (2021), Beaudouin-Lafon, Bødker, and Mackay talk about "generative theories". In section 2.1, these are defined as

- (1) grounded in a theory of human activity and behavior with technology;
 - (2) amenable to analytical, critical and constructive interpretation; and
 - (3) actionable through the theory's concepts and generative principles.
- and three resulting lenses, applied in sequence - analytical, critical, and constructive.

Could these notions of theory and lenses help us organise our discipline?