Connecting Artistic and Logical Reasoning: The Bento Box as a Conceptual Tool for Logic Programming Education in Art and Design.

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Abstract

In the winter semester 2025/26, I began to explore the question of to what extent a Bento Box could serve as a useful mental model for providing art and design students in my introductory course of logic programming with an accessible entry point and for enabling an intuitive understanding of its fundamental concepts in relation to concepts of composing an aesthetic artifact. I started to examine the Bento Box with regard to its capacity to embody these qualities and made a series of interesting discoveries, which I discuss in this paper.

Keywords

Generative Logic, Simple Generative Logic Grammars, Containment Relation, Structuralism, Education, Logic Programming, Logical Thinking

From instrumental competence to conceptual integration: Exploring Generative Logic.

The core idea of my educational framework Exploring Generative Logic (EGL) [1] is to get students of art and design in touch with logical thinking through the creation of aesthetic objects using logic programming. A central objective of the EGL framework is not merely to introduce students of art and design to the practical use of logic programming as a technical instrument, nor solely to cultivate a functional understanding of its underlying principles.

Rather, the program aspires to enable the students to relate the field of logic programming, and, by extension, the broader domains of logic, mathematics and computer science, to the aesthetic process of creation on a deeper intellectual level.

The emphasis thus shifts from instrumental competence to conceptual integration: students are encouraged to understand logic programming as a formative principle that can meaningfully inform and structure artistic practice.

In order to achieve this objective, I initially adopted a structuralist methodology through which I sought to trace the ostensibly distinct domains of art, logic, computer science, and mathematics back to a common principle of organization underlying them all.

Rather than treating these fields as separate or only loosely connected, this approach reveals their shared foundation by identifying structural correspondences that operate across disciplinary boundaries.

Following a thorough and systematic analysis, I identified the containment relation as the unifying form of order that lies at the foundations of these domains, understood in the sense articulated by Jean Piaget, namely that one form can be contained within another and that complex structures arise through the hierarchical embedding of such forms. [2]

According to Piaget, this concept of containment is not limited to a single domain; it manifests in logical expressions, mathematical structures, computational systems, and aesthetic compositions alike. In each case, meaning and organization are generated through relations of inclusion, nesting, and structural dependency.

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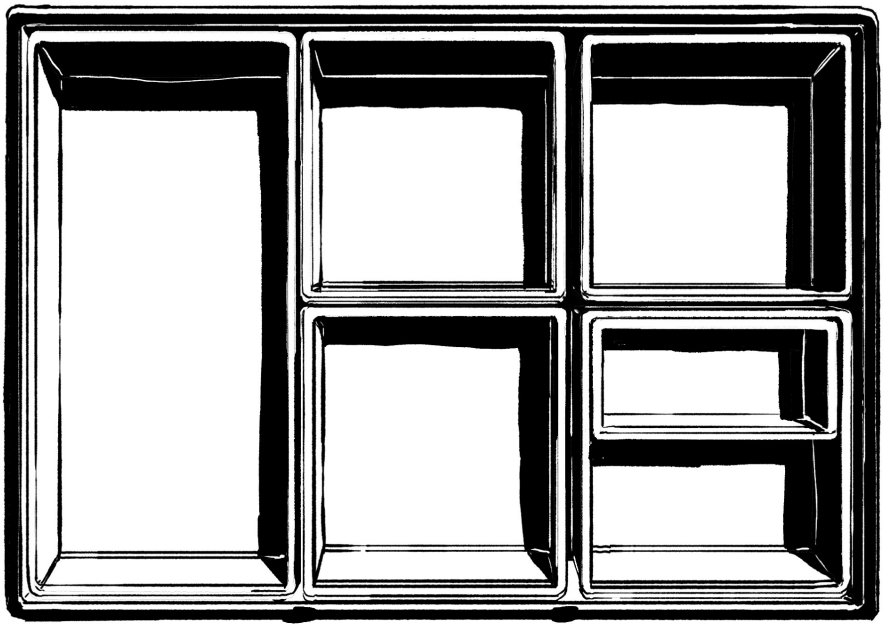


Figure 1: The Bento Box Principle: a nested structure of empty positions that can be filled with selected items. Illustration: Frank Höhne

Discovering the Bento Box.

Having identified, through the notion of the containment relation, the order type to which both logical programming and, by extension, logic, computer science, and mathematics, as well as the aesthetic process of design can be reduced, the subsequent step consisted in determining an appropriate didactic object.

This object needed to render the abstract principle perceptible and intelligible, enabling students to apprehend its structural significance in a concrete and intuitive manner.

The challenge, therefore, lay not merely in theoretical articulation, but in the translation of an underlying formal unity into a form of representation capable of bridging abstraction and experience.

When I was looking at a Bento Box in a Japanese household goods store in Düsseldorf in October 2025, the thought suddenly occurred to me that such a Bento Box might serve as a didactic object through which this abstract principle could be rendered accessible and tangible within the classroom.

Over the course of the winter semester, I started to examine the Bento Box with regard to its capacity to embody these qualities and made a series of discoveries, which I present in this paper as arguments for its use as a didactic tool within the framework of Exploring Generative Logic.

The Bento-Box and the containment-relation.

Items or boxes inside boxes that are themselves contained within a box: The Bento Box is a tangible embodiment of the containment relation, whose defining characteristic is that one form becomes the content of another form. According to Jean Piaget, this “containment relation”

("Einschachtelungsbeziehung") belongs to the elementary ordering relations — that is, to the most fundamental ways in which humans perceive and construct structures in the first place. [2]

This structure is therefore shared by a wide variety of human creations which, at first glance, seem to have nothing in common, but which, upon closer inspection, reveal themselves to be structurally equivalent.

Seen from this perspective, the form of the Bento Box becomes a means of challenging the widespread assumption that making art, on the one hand, and logic, mathematics, or writing computer programs, on the other, belong to entirely separate domains of knowledge.

Using the Bento Box as a mediating model, it becomes clear that all of these practices share common conceptual ground: they organize elements through relations of inclusion, structure parts within wholes, and generate meaning through ordered containment.

The Bento-Box and Max Bense's concept of composition.

In order to create an aesthetic object with digital tools You need to understand what a composition is.

Because even if the object might appear as a single, indivisible whole on the display it is a combination of discrete elements.

For this reason, my educational framework, particularly in how it conceptualizes the design of an aesthetic object, is based on Max Bense's definition of composition, as he occupies a key position in establishing a viable theoretical foundation for aesthetic practice involving the computer.

According to Bense, a composition is "the distribution of material elements within spatiotemporal schemata." [3] What is most important to me in Bense's approach is his distinction between the elements, their distribution, and the spatial or temporal scheme into which the elements are arranged. I interpret such a scheme as a Leerstellenstruktur (a configuration of empty spaces).

In other words, a composition consists of a configuration of distinct positions that are empty by default but can be filled with a selection of material elements. The materiality of these elements determines the materiality of the aesthetic object that serves as the physical manifestation of the composition, because it is the "Realisat" (realized form, Result) of its composition. [4]

The consequence of this structure for the artistic process of composition is that it divides into three interrelated operations, which together work to create a composition: the selection of material elements, the creation of the configuration of empty positions, and the placement of the material elements into those designated empty positions within the configuration.

This definition of a composition and the process of composing operates at a high level of theoretical abstraction. The advantage of this approach is that it can describe all types of aesthetic objects, ranging from poems and music to films, paintings, and sculptures, whether analog or digital. The disadvantage of it is, that it can be difficult for students to grasp.

But with the Bento Box as a visual model, I seem to have found an object that enables students to grasp this mental model of a composition more easily, making the basic ideas of his definition tangible while representing its key characteristics in a one-to-one relationship and in a particularly clear and illustrative way.

Why do I think that this is the case?

Imagine a Bento-Box: A Bento-Box consists of an outermost bounding box that serves two fundamental purposes. First, it defines the overall size and limits of the whole. Second, it contains an internal configuration of smaller boxes. These boxes may be identical in size or vary. They may remain empty or be filled, and some boxes can themselves contain other boxes, creating nested structures. Each box can be filled with carefully chosen items, whose placement is deliberate.

Now recall Max Bense's definition of composition, as I interpret it: a composition consists of a configuration of distinct positions, that are empty by default but can be filled with a selection of material elements.

It is easy to see that a Bento Box offers a clear visual model of this definition of composition: The configuration of boxes, seen as a finite structure of voids or placeholders, embodies the configuration of empty positions. And each box within that configuration represents one of these distinct positions, in which a material element may be placed.

Because the Bento Box includes all elements necessary to function as a demonstration object, it renders an abstract definition of composition tangible. It helps students train their eye to recognize the core components of a composition within the framework of my educational approach.

This enables students to quickly grasp the composition of aesthetic objects of any kind, offering a clear and cognitively economical way of understanding both structure and material elements within it.

The Bento Box model thus lowers the threshold for engaging with artistic composition by providing an immediately accessible and familiar mental model.

But this is not all. The Bento Box can also serve to illustrate how this concept of composition may be formulated as a logical grammar. In this way, it has the potential to build a bridge for students from aesthetic thinking to logical thinking and logic programming.

The Bento Box as conceptual interface connecting artistic with logical reasoning.

Because the Bento Box embodies, in its very form, Max Bense's concept of composition, it can also be used directly as a framework for constructing a logic grammar that represents this concept.

We can use production rules, the basic structural construct of a logic grammar, to formally describe the structure of a Bento Box.

A production rule has the basic form: Head –> Body.

The arrow (–>) can be interpreted in different ways, and we will make use of this interpretive flexibility. At its most basic level, however, the arrow expresses the idea that the Head consists of the Body. In other words, the category on the left-hand side is structurally composed of the elements on the right-hand side.

Let us now recall the structure of a Bento Box: The outer box contains a configuration (i.e. spatial arrangement) of inner boxes; each of these boxes in turn contains either another box or an item, and so on, whereby we can decide the level of recursion.

It is straightforward to formulate this recursive structure or subsets of it as a set of production rules in a one-to-one manner.

All we need to do is shift the interpretation of the arrow from "consists of" to "contains":

```
outer_bento_box -> configuration_of_inner_boxes.
inner_boxes -> items.
```

In this reinterpretation, the arrow no longer expresses structural constituency in the strictly linguistic sense, but rather a containment relation. This illustrates how the formal mechanism of production rules can be conceptually reinterpreted while preserving its compositional structure. Using this Bento-Box scheme, declarative descriptions of aesthetic objects of all kinds can be easily formulated as logical grammars in Prolog code. The number of inner boxes and items can be expanded arbitrarily, as can the depth of recursion, allowing aesthetic objects with complex structures to be described in a straightforward manner. To this end, I developed the Simple Generative Logic Grammar (SGLG), another central component of my educational framework.[5]

Here is an example for a straightforward description of an aesthetic object in form of a SGLG:

```
outer_box -> inner_box_a, above, inner_box_b, above, inner_box_c.
inner_box_a -> e_01, e_02, e_03, e_04, e_05.
inner_box_b -> e_01, e_02, e_03, e_04, e_05, e_06, e_07.
inner_box_c -> e_01, e_02, e_03, e_04, e_05.
```

This SGLG can be read as follows:
The outer box contains a configuration of 3 inner boxes.
The boxes are arranged vertically, with inner_box_a on top, as indicated by the term 'above'.
The first box contains 5 elements lined up in a row, the second box contains 7 elements lined up in a row and the third box contains again 5 items again lined up in a row.

This is the description of the structure of a Haiku, viewed through the lens of the Bento Box Model.

A Haiku is a traditional Japanese poem consisting of three lines: the first line contains 5 syllables, the second line 7, and the third line 5.

Here is a full Prolog code describing a Haiku from Basho [6] in form of a SGLG:

```
%A Haiku contains 3 lines, arranged vertically, with line_a on top:
haiku --> line_a, above, line_b, above, line_c.

%line a contains 5, line b 7 and line c 5 boxes arranged in a row:
line_a --> a_01, a_02, a_03, a_04, a_05.
line_b --> b_01, b_02, b_03, b_04, b_05, b_06, b_07.
line_c --> c_01, c_02, c_03, c_04, c_05.

%Each of these boxes contains one syllable:
a_01 --> "an".
a_02 --> "old".
a_03 --> "si".
a_04 --> "lent".
a_05 --> "pond".

b_01 --> "a".
b_02 --> "frog".
b_03 --> "jumps".
b_04 --> "in".
b_05 --> "to".
b_06 --> "the".
b_07 --> "pond".

c_01 --> "splash".
c_02 --> "si".
c_03 --> "lence".
c_04 --> "a".
c_05 --> "gain".

%The box labeled "above" contains the information for the Prolog interpreter to place
    the next box or item beneath the preceding one:
above --> "\n".

%The "output"-rule is the entry-point for the generation process:
output :- phrase(haiku, Ls), format("~s", [Ls]).
```

The output will be:

an old silent pond
a frog jumps into the pond
splash silence again

The examples show: Regardless of which aesthetic object is modeled in this way as a logic grammar: The resulting grammar is a direct formalization of the object's compositional structure itself. Viewed this way, the Bento Box functions as a conceptual interface: a mediating mental model that allows compositional thinking across the arts to be seamlessly translated into logical grammars. It enables artists and designers to move between artistic compositional thinking and logical reasoning within a single, shared organizational principle.

Simple Generative Logic Grammars: Extending DCGs' Implicit Layout Conventions into Artistically Useful Layouts.

One remark about the Simple Generative Logic Grammar (SGLG) concept introduced in [5] may be appropriate here. Within the SGLG formalism I am taking the implicit layout convention already

present in DCGs, namely that elements written sequentially in the grammar are directly translated into a corresponding sequential order in the output, and completing this implicit layout model by adding a second, vertical dimension. For the Haiku code example, I implemented this using the "above" primitive, which is realized as a meta-production rule. This rule employs the built-in Prolog predicate for line breaks, available across Prolog systems, to cause the Prolog engine to place elements beneath each other.

With this small extension, complex two-dimensional structures can be described and generated straightforward. The structure of the grammar directly reflects the final visual form that will be generated in two dimensions. A separate geometric engine is not required; the grammar itself contains all the information about structure, order, and projection.

As a result, the logic-grammar formalism becomes an accessible and highly intuitive tool for artistic applications, making the generation of aesthetic objects through code both simple and transparent. Its conceptual clarity and ease of use provide an intuitive entry point to this style of programming, making it particularly well suited for introducing art and design students to logic programming.

In the SGLG workflow, Prolog's inference engine is used compositionally to place components that satisfy specific constraints within configurations described by SGLGs. To further extend the application of the logic-grammar formalism beyond its traditional linguistic domain, where sequentiality is the primary organizing principle, into the two-dimensional realm of artistic composition, it may be worthwhile to incorporate a primitive for vertical arrangement directly into the DCG processor as a standard feature. Such an addition would provide a natural foundation for future developments, potentially giving logic grammars the expressive power to describe and generate three-dimensional structures as well.

The step from the arts into logic and mathematics: Interpreting rules in Prolog as containment-relations.

Let us now take a closer look at the shift from the consists-of relation to the containment relation in the above Haiku example. This shift occurs in order to interpret the arrow (–>), from the outset, as expressing containment rather than mere structural composition.

The reason for this shift is methodological: understanding the arrow as a containment relation does not only take into account George Spencer Brown's idea that "logic itself can be reduced to containment patterns" [7]

It also allows for a smoother conceptual transition to the classical Prolog rule operator " :- ".

Within the framework of my EGL education program, I introduce the construct ":-" as a notation for a containment relation, in order to maintain a set-theoretic reading of logical implication. Under a declarative semantics of Horn clauses, the expression "conclusion :- condition(s)" can be understood in terms of set inclusion, where the set of states satisfying the conditions is contained in the set of states satisfying the conclusion.

By grounding both the arrow (–>) and the (:-) in a containment interpretation, the move from grammatical production to logical implication becomes conceptually transparent.

This containment-based perspective provides the foundational interpretation from which further meanings of the construct ":-" along with the concept of implication across different logical systems and contexts can be systematically developed and studied.

But the decision for the containment-based perspective within EGL has an even more far-reaching reason.

The Bento Box: Connecting logic grammars with fields of knowledge, from sound and vision to philosophy.

Together with the property that the Bento Box represents a concretization of the containment relation, there is another aspect that turns the Bento Box into a cognitive tool that can be used within the educational framework of EGL to explore connections between different epistemic contexts and fields of knowledge.

The fact that the configuration of empty boxes represents a finite structure of empty positions or placeholders makes the Bento Box a visual model with significant connective capacity.

The empty boxes can be understood as determinate positions that are structurally given yet semantically open and awaiting determination. In this way, the model readily supports the establishment of conceptual links to a wide range of concepts and theoretical frameworks.

For example, using this model we can easily step from the visual world into the world of sound. An electronic 16 step sequencer is structured in exactly the same way.

It consists of a configuration of 16 steps, that is 16 empty positions. A sound or a pitch can be assigned to each of these positions. The sequencer's task is then to play back this sequence.

At this point it becomes clear how easily a step sequencer can be modeled as a logic grammar by applying the Bento Box model.

The step into philosophy is not far either. One example here is Gotthard Günther's Kenogrammatik [8], which forms part of his project of a many-valued, polykontexturale Logik and is situated within the context of his engagement with classical logic, cybernetics, and a theory of reflexive systems.

Günther's Kenogrammatik shares with the Bento Box the concept of a configuration of empty positions that can be filled with different elements. This deep structural homology provides the point of departure for an in-depth exploration of the kenogrammatic concept with regard to its generative potential in the context of art and design, a line of inquiry I am currently developing.

The concept of a configuration of empty positions that can be filled with different elements corresponds to one of the foundational concepts in philosophy: the distinction between form and matter. Aristotle developed the distinction between form (eidos/morphē) and matter (hylē) in the context of his theory of hylomorphism, according to which every physical object is composed of form and matter. [9].

Towards a Theory of Artistic Composition as Problem-Solving.

Contemplating different organizations of boxes inside a Bento Box, and understanding composition as the "putting of things into boxes" [7], or more generally as the establishment of containment relations[7], suggests an interpretation of artistic composition as a problem of completion.

Like a Bento Box containing an arrangement of empty boxes waiting to be filled, the aesthetic object appears as a configuration of empty positions. As Cornelius Castoriadis, citing Maurice Merleau-Ponty, observes with regard to the act of writing: "At the beginning, the 'intention of meaning-giving' is only a 'specific emptiness that is to be filled with words.'" [10] Indeed: The challenge of the compositional process lies in filling these empty positions with elements, once the decision has been made how these empty positions are to be arranged within the boundaries of the object. In other words, this model of the compositional process clearly distinguishes between the structural and the content level of composition.

The degree to which an aesthetic object remains indeterminate during the creative process depends on how precisely the arrangement of its empty positions is specified, how many positions remain unfilled, which basic forms are selected, and how each form is mapped onto a corresponding position.

As shown above with the Haiku example, a logic grammar can be used to describe the "partially unknown aesthetic object" [1] that is, the configuration of empty positions, the repertoire of basic forms selected by the artist, and the production rules governing which empty position is to be filled with another empty position or with which basic form.

The standard inference engine of a Prolog system can then be employed to execute the filling of the empty positions of this partially instantiated object in a top-down manner.

This process unfolds in two steps. In the first step, the inference engine searches the repertoire of basic forms according to the structural mapping between empty positions and basic forms defined by the grammar. In the second step, the engine fills the empty positions of the aesthetic object by inserting the matching basic forms, such as, in the case of a Haiku, strings of syllables, into their corresponding positions.

From a theory-building perspective, generating a work of art by formulating a logic grammar and employing Prolog's inference engine amounts to a step toward an operational theory of artistic composition.

It seems to me that these initial, tentative steps already suggest that artistic production may be understood as the completion of an incomplete aesthetic object. Indeed, the "achievement goal" [11] is to change the state of the object being generated by filling its empty positions. In other words, artistic production may be understood as a form of problem-solving that transforms the state of knowledge about an object of interest from unknown to known. And as Bob Kowalski has shown in his seminal work Logic for Problem Solving, logic programming provides a particularly powerful framework for this purpose.[12]

Discussion and Outlook.

As I have sought to argue in this paper, I propose to use the notion of containment, exemplified by the Bento Box as a conceptual interface, as the central entry point in my introductory course on logic programming for students of art and design.

The aim is to provide with EGL a framework through which these students can relate their existing modes of artistic thinking directly to forms of logical reasoning.

At the same time, I am fully aware that approaching the concepts of logic programming from this perspective does not exhaust their formal and computational complexity. A case in point is the metaphor of "empty positions" and their "filling," introduced in the previous chapter to describe the operation of a Prolog inference engine. While this metaphor effectively conveys the idea of completion through insertion, it does not fully capture the concept of unification. In particular, it underrepresents the symmetrical nature of unification, in which both sides of a relation are evaluated for compatibility, rather than one side simply being filled by the other. The metaphor of empty positions and filling thus offers an intuitively accessible, yet only partially adequate, analogue of the underlying logical process.

This reduction, however, is a deliberate and productive one. The pedagogical goal is not to present a fully formal account at the outset, but to shape the first encounter with logic programming in such a way that it does not become an experience of alienation for students of art and design. Instead, it should be an inspiring and eye-opening moment. One that enables them to perceive logic not as an external or foreign domain, but as something that can be meaningfully related to their own practice of artistic composition. In this way, students gain an initial, operative understanding that allows them to engage with logic programming experimentally and creatively, and to gradually approach more complex concepts over time.

Ultimately, with EGL I seek to position logic programming in the minds of the students, as well as its mathematical and computational foundations, as integral components of the aesthetic design process itself. The emphasis lies on uncovering correspondences between logical structures and artistic processes—between deduction and composition, constraint and form-generation, symbolic representation and visual or spatial articulation. Through this integration, students develop the capacity to approach artistic creation not only intuitively, but also as a mode of inquiry in which formal reasoning and aesthetic thinking are deeply intertwined. By relating art, logic, computer science, and mathematics through their shared principle of order, EGL opens an interdisciplinary space for thinking that cultivates a form of literacy in which analytical precision and artistic intuition are understood not as opposing forces, but as mutually generative dimensions of creative work.

I think that the connective capacity of the Bento Box I have discussed in this paper, indicates its potential to function as a key thinking tool within my EGL framework for achieving these goals. I plan

to explore this potential experimentally in the coming semesters. In these experiments, I assume that, when the Bento Box is used consistently in teaching, the following assumptions will be confirmed:

1. The shared perspective the Bento Box provides makes underlying similarities across different fields of knowledge and practice visible to students.
2. By working with the same conceptual tool across domains, students will come to recognize connections between disciplines of rational and aesthetic thinking, such as logic and artistic composition, which initially appear distinct.
3. Students will also be able to seamlessly translate artistic compositions into logical structures.
4. The clarity of the Bento Box's form of representation enables students to analyze compositional structures more deeply and to experiment with them at a higher level of insight.
5. As a conceptual interface, the Bento Box provides a foundation for understanding the close interplay between artistic and logical thinking, in line with Charles Sanders Peirce's view that "spatial visualization is the native vocabulary of rational thinking" [7]

Whether these five assumptions are confirmed by the experiments will be discussed in a subsequent paper.

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Note on Translations

All translations from non-English sources were produced by the author, with the exception of Matsuo Bashō's haiku, which is taken from William J. Higginson's translation.

Declaration on Generative AI

During the preparation of this work, the author used ChatGPT in order to: translate text and, grammar and spelling check. After using this tool, the author reviewed and edited the content as needed and take full responsibility for the publication's content.

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