A Conceptual Framework for Analogy-Based Design-Concept Generation in Architectural Design Pedagogy: The Identification–Abstraction–Translation Model and a Domain-Consistency Test for Biomimicry

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Abstract
This paper advances a conceptual framework for teaching design-concept generation in architectural design studios, in which analogy functions as the principal cognitive mechanism by which students move from an inchoate design intention to a communicable spatial idea. Rather than offering a systematic review of the field, the paper draws selectively on design-cognition literature — Broadbent's taxonomy of design modes, Casakin and Goldschmidt's experimental studies of visual analogy, Nazidizaji and colleagues' work on analogical reasoning ability, and Gero's function–behaviour–structure ontology — to warrant an original three-stage model, Identification–Abstraction–Translation (I–A–T), that operationalises analogical design thinking as a teachable studio procedure. From this model the paper derives three formal, empirically testable propositions: that a valid design concept requires the identified analogy to remain traceable across the layout, spatial-relationship, and form concept registers (P1); that biomimicry constitutes a valid design driver only where it satisfies a proposed domain-consistency test between the architectural problem's logic and the biological system's logic (P2); and that analogical design competence is trainable through explicit, staged instruction rather than left to intuition (P3). The paper closes by translating these propositions into implications for studio curriculum sequencing, critique protocols, and assessment criteria, and by outlining a programme of controlled studio-based research to test them.

Keywords: *design-concept generation; analogical reasoning; form abstraction; biomimicry; architectural design pedagogy; spatial concept*

1.Introduction

1.1 Background to the Study

Concept generation occupies a paradoxical position in architectural design education. Studio instructors routinely demand that students "find a concept," yet few curricula articulate, in operational terms, how a concept is actually produced.

1.2 Statement of the Problem

Left unstructured, students most often default to superficial resemblance — a building shaped like a flower, a faculty organised to resemble a tree — in which an image is borrowed but no

functional, spatial, or organisational logic is transferred with it. Such gestures are frequently mistaken for design concepts when they are, in Broadbent's (1973) terms, merely iconic copying rather than analogic invention. This confusion is not confined to analogy in general. Biomimicry, in particular, is frequently conflated with biophilic design in student work — a fern-patterned screen is often presented as "biomimetic" when it is, in fact, biophilic decoration — compounding the underlying pedagogical problem with a second, more specialised category error that studio critique rarely has the vocabulary to name.

1.3 Aim and Objectives

This paper argues that concept generation can be taught explicitly, as a disciplined cognitive procedure rather than an innate talent, by adopting a three-stage pedagogy: identification of an analogy in a source domain, abstraction of that analogy to its essential, non-literal characteristics, and translation of the abstracted characteristics into one or more of three recognised concept registers — the layout concept, the spatial-relationship concept, and the form concept.

Central to this framework is the claim that a genuine design concept is one in which the identified analogy remains traceable across whichever register it informs: an analogy invoked for massing should, at least in principle, be defensible in terms of organisation and experiential sequence, even where a given project chooses to develop only one register in depth. Where this traceability cannot be demonstrated, the analogy has not been translated but merely applied as decoration. The paper extends this argument to biomimicry, which it treats not as a stylistic movement but as a specialised, conditional subclass of analogical design. Following Benyus (1997), biomimicry is defined by its emulation of biological strategies, structures, and processes to solve human design problems; this position it firmly within — rather than outside — the analogical design tradition described by Broadbent and later cognitive researchers. The paper proposes that biomimicry should be adopted only where the underlying logic of the architectural problem is consistent with the underlying logic of the biological system invoked, and it offers a domain-consistency test that studio instructors can apply when adjudicating student work.

The specific objectives of the paper are to:

(i) situate the design concept within design-cognition theory, using Gero's function–behaviour–structure ontology, and consolidate the layout, spatial-relationship, and form concept registers into a single teachable vocabulary;

(ii) review selected empirical evidence on analogical reasoning in design learning to warrant the claim that analogical competence is trainable;

(iii) develop the Identification–Abstraction–Translation (I–A–T) model and formalise the traceability requirement across the three concept registers;

(iv)theorise biomimicry as a conditional analogical domain and develop a domain-consistency test for adjudicating its use as a design driver;

(v) derive implications of the framework for studio curriculum sequencing, critique protocols, and assessment criteria; and

(vi)outline an agenda of controlled, studio-based empirical research to test the paper's propositions.

From the argument developed across the paper, three propositions are advanced and elaborated at the point in the argument where each arises. Proposition 1 (P1): a design concept is valid only if the identified and abstracted analogy remains traceable, at least in principle, across the layout, spatial-relationship, and form concept registers, regardless of which register or registers a given

project develops in depth. Proposition 2 (P2): biomimicry functions as a valid design-concept driver only when the functional, organisational, or performative logic of the architectural problem is consistent with the functional logic of the biological system serving as the object of mimicry — the domain-consistency test — and collapses into decorative, iconic reference where this consistency is absent. Proposition 3 (P3): analogical design competence is not a fixed trait but a trainable capacity, such that explicit, staged instruction in identification, abstraction, and translation will produce more valid and traceable design concepts than unstructured, intuition-based studio pedagogy.

1.4 Justification of the Study

The practical stakes of this gap are significant for studio pedagogy. Where concept generation is left to intuition, critique tends to reward superficial novelty over demonstrable design logic, and biomimicry in particular is vulnerable to becoming a fashionable image-source divorced from the functional reasoning that gives it explanatory force. A framework that operationalises analogical reasoning as a staged, teachable procedure, and that supplies studio instructors with an explicit test for adjudicating biomimicry, stands to demystify concept generation for students and to raise the theoretical rigour with which biomimetic design is taught and assessed across architectural curricula.

2. Literature Review

2.1The Design Concept as Generative Structure:

The Function–Behaviour–Structure Ontology

Gero's (1990) function–behaviour–structure (FBS) framework, later elaborated with Kannengiesser as the situated FBS ontology (Gero & Kannengiesser, 2004), offers a useful account of where the design concept sits within the broader design process. In this ontology, a design begins with a set of required functions (F), which the designer translates into expected behaviours (Be) and, eventually, into structure (S) — the concrete components and their relationships. The design concept can be understood as an early, provisional mapping from function to a generative structural idea, produced before the structure is fully resolved. It is generative in the sense that it constrains and organises the many subsequent decisions of layout, section, envelope, and detail, without itself specifying them. This is precisely why a borrowed image without an underlying organisational logic fails as a concept: it supplies a structure (S) with no defensible route back to function (F) or behaviour (Be).

2.2 Three Registers of the Design Concept

No single source in architectural theory offers exactly the three-part taxonomy proposed here under these names; it is this paper's own consolidating synthesis, built by drawing together several overlapping and independently established strands of architectural design theory. Ching (2023) treats form, space, and order as the primary categories of architectural composition, providing the theoretical basis for distinguishing form from spatial experience as separate dimensions of a design. Clark and Pause (2012) document recurring organisational concepts and formative ideas across more than one hundred architectural precedents, establishing that organisation in plan is itself a distinct, nameable category of design concept rather than a by-product of form. White (1975) catalogues a vocabulary of diagrammatic concept-types developed specifically for design pedagogy, evidencing that studio teaching has long relied on naming and classifying concept types as a teaching device. Eilouti (2018) theorises the channels

through which an architectural concept is translated from idea into built form, supporting the claim that a single generative concept typically requires translation across more than one register of the design. This paper consolidates these overlapping strands into three explicitly named registers, chosen for their clarity and teachability in studio settings, each addressing a different dimension of the architectural problem:

2.2.1 Layout concept — the organisation and adjacency of programme and function in plan: zoning, hierarchy of access, distribution of served and servant spaces, and the logic governing how parts relate to the whole in plan.

2.2.2 Spatial-relationship concept — the experiential and perceptual relations between spaces: sequence, procession, enclosure and release, thresholds, hierarchy of scale, and the qualitative character of movement through the building.

2.2.3 Form concept — the massing, geometry, structural order, and envelope logic that give the building its physical and volumetric identity.

The tripartite nomenclature of layout concept, spatial-relationship concept, and form concept is thus proposed here as a terminological contribution in its own right, intended to consolidate the categories found across this literature into a single, teachable vocabulary for studio use, rather than as a direct restatement of any one prior source. These registers are not mutually exclusive; most mature design concepts operate across two or three simultaneously. The pedagogical value of naming them separately is diagnostic: it allows an instructor to ask, of any proposed concept, which register it addresses, and whether the underlying analogy survives translation into the other registers even if only partially developed there.

2.3 Analogy within Broadbent's Taxonomy of Design Modes

Broadbent (1973) distinguished four modes by which architects historically generate design solutions: pragmatic design, which manipulates available materials and construction methods without innovation; iconic design, which treats a prior successful solution as a template to be copied; canonic design, which applies rules, grids, and proportioning systems as generative resources; and analogic design, which draws on resemblance to a source outside the building task itself — whether natural, mechanical, or cultural — to generate a novel structural or organisational idea. Of the four, analogic design is the mode most associated with inventive, rather than repetitive, outcomes, because it imports an external logic that has not previously been tested against the architectural problem at hand. The pedagogical task, therefore, is to train students in the disciplined use of the analogic mode while helping them distinguish it from mere iconic copying, with which it is frequently confused in student work.

2.4 Empirical Evidence for Analogy in Design Learning

A substantial body of design-cognition research supports the claim that analogical reasoning can be taught and that its use materially improves design outcomes. Casakin and Goldschmidt (1999) found that the use of visual analogy improved the quality of design solutions among architecture students, with the effect most pronounced among novice designers, who benefited more than experts from structured analogical prompts. In a related study, Casakin and Goldschmidt (2000) showed that explicit guidance in how to use analogy — rather than simply exposing students to analogous source material — was necessary to make the strategy accessible, particularly to less

experienced designers. Casakin's (2010) later work on visual displays and design-problem structuring further confirmed that expertise moderates how analogy is deployed, with expert designers using analogy more selectively and at a greater conceptual distance from the source. Together, this research indicates that analogical skill is not simply innate but is substantially trainable through deliberate studio pedagogy.

Complementary evidence comes from Nazidizaji, Tomé, and colleagues, whose studies found a correlation between architecture students' visual-spatial reasoning — as measured by tests of nonverbal analogical reasoning — and their design-studio performance, suggesting that the capacity to reason by analogy is a distinct and measurable component of design aptitude that studio pedagogy can and should scaffold explicitly rather than assume. Research reported in the Role of Analogy in Architecture Design Education literature similarly found that students given structured instruction to draw on analogous building cases significantly improved their problem-solving performance in concept design tasks compared with unstructured control conditions.

Design-by-analogy research more broadly, including studies of near-domain and far-domain analogical distance, indicates that analogies drawn from distant, less obviously related domains are more likely to produce genuinely novel design outcomes than analogies drawn from within the same building type, though far-domain analogy is cognitively more demanding and therefore requires more deliberate pedagogical scaffolding (Moreno, Yang, Hernández, & Wood, 2014).

Taken together, this literature warrants Proposition 3: analogical design competence is not a fixed trait but a trainable capacity, such that explicit, staged instruction in identification, abstraction, and translation will produce more valid and traceable design concepts than unstructured, intuition-based studio pedagogy.

2.5 Biomimicry: Definition, Distinction from Biophilia, and Levels

Biomimicry, as defined by Benyus (1997), is the interdisciplinary practice of observing and emulating nature's strategies, structures, and functions to develop innovative solutions to human design problems. It should be distinguished from biophilic design, articulated by Kellert, Heerwagen, and Mador (2008), which is concerned with satisfying an intrinsic human affinity for nature by incorporating natural materials, light, vegetation, and analogues of natural pattern into the built environment for psychological and physiological benefit. Biophilia is oriented toward the experience of nature; biomimicry is oriented toward the emulation of nature's functional logic. The two are frequently conflated in student work — a fern-patterned screen is often presented as “biomimetic” when it is, in fact, biophilic decoration — and this paper treats the distinction as a necessary prerequisite for evaluating biomimetic design concepts in the studio. Benyus's framework further distinguishes three levels at which biomimicry can operate: the organism level, which mimics the form or appearance of a specific organism; the behaviour level, which mimics how an organism behaves or relates to its context, including its adaptive or responsive strategies; and the ecosystem level, which mimics how a whole ecosystem functions, including principles such as interdependency, closed-loop resource cycling, and resilience through diversity. These three levels map with reasonable consistency onto the three concept registers developed in Section 2.2: organism-level mimicry most often informs the form concept, since it concerns morphology and geometry; behaviour-level mimicry most often informs the spatial-relationship concept, since it concerns adaptive response, circulation, and environmental behaviour over time; and ecosystem-level mimicry most often informs the layout concept, since it concerns the distribution and interdependency of programmatic parts. This mapping is a further diagnostic tool: it allows an instructor to identify, quickly, which level of biomimicry a student

has engaged and whether the chosen level is adequate to the register the project claims to address.

2.6 Synthesis and Research Gap

Read together, this literature converges on a single, underexploited pedagogical opportunity. Design-cognition theory (Gero, 1990; Gero & Kannengiesser, 2004) explains why an unabstracted image fails as a concept: it supplies structure without a defensible route back to function. The precedent and pedagogy literature (Ching, 2023; Clark & Pause, 2012; White, 1975; Eilouti, 2018) establishes that a mature concept typically operates across more than one register of the design, yet stops short of naming those registers as a single, teachable taxonomy.

Broadbent's (1973) taxonomy distinguishes analogic invention from iconic copying, and the experimental literature (Casakin & Goldschmidt, 1999, 2000; Casakin, 2010; Nazidizaji et al., 2015; Moreno et al., 2014) demonstrates that the analogic mode is trainable rather than innate, but stops short of specifying the staged procedure by which it might be taught. Benyus's (1997) biomimicry framework and its distinction from biophilic design (Kellert et al., 2008) supply a rich substantive domain for analogy but offer no explicit test for when that domain is legitimately invoked. The gap this paper addresses is the absence of a single model that consolidates the concept registers into one teachable vocabulary, operationalises analogical reasoning as an explicit, staged studio procedure, and supplies a screening test for the specific case of biomimicry — the task taken up in Sections 4 and 5.

3.Methodology

This is a conceptual, rather than empirical or systematic-review, paper. Following MacInnis's (2011) framework for conceptual contributions, a conceptual paper differs from a systematic or narrative literature review in that its aim is not to comprehensively map or synthesise a body of scholarship, but to use selected literature as warrant for an original model, typology, or set of relationships, offered as propositions for future empirical testing. This paper is conceptual in that sense: its literature engagement in Section 2 is purposive rather than exhaustive, and its contribution is the I–A–T model and the three formal propositions it generates, not the literature review itself. Three methodological moves follow from this stance. First, sources were selected because each supplies a specific, load-bearing warrant for one component of the model: Broadbent's (1973) taxonomy warrants the analogic/iconic distinction on which the whole framework rests; Gero's (1990) function–behaviour–structure ontology warrants the claim that a concept is a generative structure rather than a decorative image; the precedent and pedagogy literature (Ching, 2023; Clark & Pause, 2012; White, 1975; Eilouti, 2018) warrants the three concept registers; the experimental design-cognition literature (Casakin & Goldschmidt, 1999, 2000; Casakin, 2010; Nazidizaji et al., 2015; Moreno et al., 2014) warrants Proposition 3; and Benyus (1997) together with Kellert et al. (2008) warrant the biomimicry/biophilia distinction underlying Proposition 2. Second, the paper proceeds by deduction rather than induction: the I–A–T model and its three propositions are constructed as a theoretical synthesis of the reviewed literature, not derived from coded empirical data. The domain-consistency test developed in Section 5 is illustrated, rather than empirically validated, through two contrasting cases — the termite-mound/Eastgate Centre analogy and a counterfactual flower-petal analogy — selected because together they allow the logical structure of the test to be demonstrated within a single, contained comparison, not because they constitute a systematic or representative sample of biomimetic practice.

Third, and consistent with its status as a conceptual paper, no claim of statistical generalisability, inter-rater reliability, or effect size is made anywhere in this paper. Propositions 1 through 3 are offered in conceptual form, for the controlled, studio-based empirical research outlined in Section 7, and the paper's own contribution is bounded by the model and the reasoning that supports it, not by data collected to test it.

4.The Identification–Abstraction– Translation Model

Building on the preceding review, this paper proposes a three-stage pedagogical model — identification, abstraction, and translation (I–A–T) — as the operational procedure by which analogical reasoning is converted into an architectural design concept. Figure 1 sets out the full procedure, including the domain-consistency screening step that applies specifically where biomimicry is proposed (Section 5) and the traceability check that applies to the translation stage (Section 4.3).

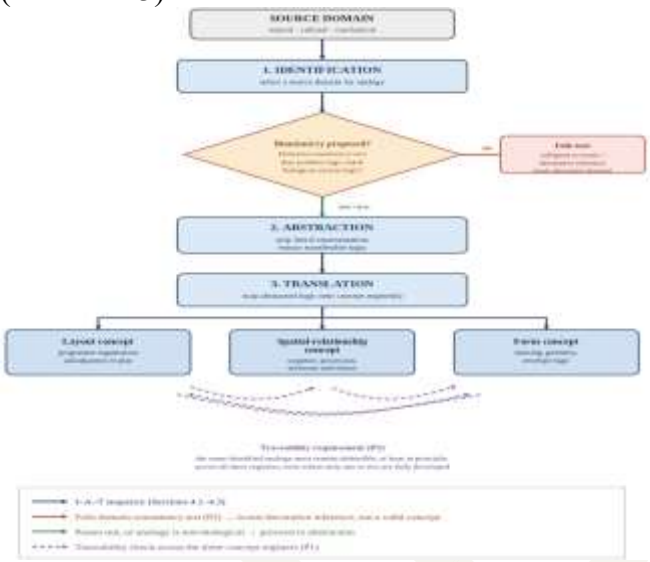


Figure 1. The Identification–Abstraction–Translation (I–A–T) model. Where biomimicry is proposed, the domain-consistency test (Section 5, Proposition 2) screens the source domain before abstraction proceeds; the translation stage maps the abstracted logic onto one or more of three concept registers, across which the identified analogy must remain traceable (Section 4.3, Proposition 1).

Stage One: Identification

The first stage requires the designer to select a source domain for analogy. Sources may be natural (organisms, ecosystems, geological processes), cultural (rituals, social structures, literary narratives), or mechanical (systems of production, movement, or exchange). Design-by-analogy research distinguishes near-domain analogy, in which the source is drawn from a closely related building type or precedent, from far-domain analogy, in which the source lies outside architecture altogether (Moreno et al., 2014). Far-domain analogy carries greater risk of superficial or unworkable transfer, but also greater potential for genuine novelty, and should therefore be introduced progressively in the curriculum, after students have first practised the discipline of abstraction described below.

Stage Two: Form Abstraction

The second, and pedagogically most critical, stage requires the designer to strip the identified source of its literal, representational characteristics and extract only those structural, organisational, or performative principles that are transferable to architecture. Abstraction is well established in basic-design pedagogy as a tool for creative thinking: architecture students who practise reducing natural or pictorial sources to their essential compositional logic — proportion, rhythm, hierarchy, growth pattern, structural principle — demonstrate improved capacity to generate original design concepts rather than literal copies (Ghom, 2017). This stage is what separates analogic design from Broadbent's iconic mode: an unabstracted analogy merely reproduces the appearance of its source, whereas an abstracted analogy carries forward only the transferable logic, discarding the source's literal representation entirely. A concept derived from a seashell, for instance, should not survive as a literal shell-shaped envelope; it should survive as a logic of proportional spiral growth, or a gradient of enclosure from a compressed core to an expansive perimeter, available for architectural redeployment.

Stage Three: Translation and the Traceability Requirement

The third stage maps the abstracted logic onto one or more of the three concept registers defined in Section 2.2. This is where the paper's central theoretical claim applies: a validated design concept is one in which the identified and abstracted analogy remains traceable across whichever register the project develops. If the abstracted logic of a spiral growth pattern is deployed as a form concept — informing massing and envelope geometry — the same underlying logic should also be defensible, at least in principle, as a spatial-relationship concept, for instance an interior sequence that expands in scale and light as one moves outward from a compressed core, and as a layout concept, for instance a programmatic distribution that places quiet or introspective functions at the core and public or high-activity functions toward the perimeter.

A project need not develop all three registers with equal intensity, but the instructor's critique should test whether the analogy could, if pressed, extend coherently into the registers left undeveloped. Where it cannot — where the form concept has no plausible bearing on layout or spatial experience — the analogy has been applied to only one surface of the design and has not functioned as a generative concept in Gero's sense of a structure that organises the whole. This is stated formally as Proposition 1: a design concept is valid only if the identified and abstracted analogy remains traceable, at least in principle, across the layout, spatial-relationship, and form concept registers, regardless of which register or registers a given project chooses to develop in depth.

5 Biomimicry as A Conditional Analogical Domain: The Domain-Consistency Test

Section 2.5 introduced Benyus's (1997) definition of biomimicry, its distinction from biophilic design, and the three levels — organism, behaviour, and ecosystem — at which biomimicry can operate, together with their approximate mapping onto the form, spatial-relationship, and layout concept registers respectively. This section develops the paper's central theoretical claim about when biomimicry may legitimately be adopted as a design driver: the domain-consistency test.

The central theoretical claim of this section, and one of the paper's principal contributions, is that biomimicry should be adopted to evolve a design concept only where the underlying logic of the specific architectural problem is consistent with the underlying logic of the biological system serving as the object of mimicry. A frequently cited case that satisfies this test is the passive-ventilation strategy of termite mounds, whose principle of buoyancy-driven air movement

through a porous structure has been credited as an influence on the Eastgate Centre in Harare, Zimbabwe. The Eastgate Centre in Harare provides a positive case through which the Identification–Abstraction–Translation model may be illustrated. The biological source was identified in the environmental-regulation principles associated with termite mounds, rather than in their external appearance. These principles were abstracted as the controlled movement of air through interconnected channels, the use of thermal mass to moderate temperature variation, the intake of cooler air and the discharge of accumulated warm air. They were then translated architecturally through ventilation ducts, concrete thermal mass, lower-level air intake, vertical exhaust routes, rooftop chimneys, shaded façades and a spatial configuration that integrates air movement with the building's atrium and occupied spaces.

The resulting building does not reproduce the visual form of a termite mound; instead, it retains the source's perceived performative logic. Eastgate therefore exemplifies the sequence **Identification → Abstraction → Translation**, in contrast to projects that proceed directly from identification to literal replication. The analogy is also traceable across layout, spatial relationship and form, while the correspondence between the biological problem of internal environmental regulation and the architectural problem of passive cooling allows the project to satisfy the proposed domain-consistency test. Nevertheless, subsequent biological research cautions against interpreting Eastgate as an exact reproduction of termite-mound physiology, since mound ventilation mechanisms differ among species and have often been simplified in architectural accounts. The project is therefore more accurately understood as an architecturally adapted biological analogy than as a literal duplication of nature.

Table 1: Traceability of the Eastgate Centre according to the I-A-T framework

I -A-T Stage	Eastgate Centre Application	Architectural Register
Identification	Termite mound selected as environmental analogue	Source domain
Abstraction	Passive airflow, thermal buffering, environmental regulation, interconnected ventilation	Abstract environmental principles
Translation	Ventilation shafts, thermal mass, atrium, exhaust chimneys, shaded facade	Architectural systems
Layout Concept	Spatial organization facilitates environmental exchange	Lyout
Spatial-Relationship Concept	Atrium and circulation spaces support airflow and environmental exchange	Spatial relationship
Form Concept	Building form accommodates environmental performance rather than biological appearance	Form

By contrast, where a design problem's underlying logic bears no relation to the biological system invoked — for example, adopting the kinetic opening and closing of a flower's petals purely for a building whose functional programme has no requirement for adaptive light, ventilation, or

privacy control — the resulting biomimicry fails the consistency test and collapses into Broadbent's iconic mode: an image is borrowed, but no functional logic accompanies it. The same kinetic petal analogy, applied to a building envelope whose actual functional problem is solar-responsive shading, would satisfy the test, because the biological behaviour and the architectural function share a common logic of adaptive response to an environmental stimulus.

There could be a scenario of conceptual sequence of 'Identification → Replication', bypassing the intermediate stages of abstraction and architectural translation as is the case of Luxor Hotels and Casino, Las Vegas, United States of America. The 'Luxor Hotel and Casino', Las Vegas, Nevada, USA, provides an instructive counter-example through which the conceptual boundaries of the proposed Identification–Abstraction–Translation (I–A–T) framework can be clarified. The project adopts two of the most recognisable symbols of ancient Egyptian civilisation—the Great Sphinx and the pyramid—as its dominant architectural vocabulary. The source domain is therefore immediately identifiable, demonstrating that the first stage of the I–A–T framework, 'Identification', has been successfully achieved. However, the design appears to proceed directly from identification to literal architectural representation, with the monumental forms of the Sphinx and the pyramid largely retained as the primary visual expression of the complex. Although the project effectively communicates an Egyptian theme and has become an internationally recognised example of themed architecture, the architectural concept is expressed predominantly through representational resemblance rather than through the abstraction and translation of transferable architectural principles. Within Broadbent's (1973) taxonomy, the Luxor Hotels and Casino project therefore aligns more closely with 'iconic design', in which recognisable forms are reproduced, than with 'analogic design', in which underlying organisational, structural, environmental, or behavioural principles are transferred from one domain to another. From the perspective of the proposed I–A–T framework, the project illustrates a conceptual sequence of 'Identification → Replication', bypassing the intermediate stages of abstraction and architectural translation. Had the design abstracted principles embedded within ancient Egyptian architecture—such as axial procession, hierarchical spatial organisation, monumental sequencing, geometric proportional systems, climatic massing, symbolic orientation, or the relationship between architecture and cosmology—and translated these principles into a contemporary architectural language without reproducing the literal forms of the Sphinx or pyramid, the resulting project would more fully exemplify analogy-based concept generation. The Luxor Hotel therefore serves not as a criticism of themed architecture, but as a valuable boundary case demonstrating that the identification of a source domain alone is insufficient to constitute a genuine architectural design concept within the proposed I–A–T framework. The National Arts Theatre, Iganmu, Lagos, Nigeria, presents a useful intermediate case through which the explanatory power of the proposed Identification–Abstraction–Translation (I–A–T) framework may be examined. The building's roof has long been described as being fashioned after a military officer's peaked cap, reflecting both the political context in which the project was conceived and the symbolic authority associated with military leadership. Within the I–A–T framework, the military cap clearly satisfies the 'Identification' stage because the source domain is immediately recognisable. The subsequent stages, however, are less evident. Although the cap may symbolically evoke authority, discipline, ceremony, and national identity, there is limited evidence that these abstract qualities were systematically translated into the building's layout, spatial organisation, circulation hierarchy, or environmental performance. Instead, the dominant conceptual expression remains the recognisable profile of the military cap itself. Consequently, the project occupies an intermediate position between

Broadbent's (1973) iconic and analogic modes of design. Unlike the Luxor Hotel, which proceeds almost directly from identification to literal replication, the National Arts Theatre incorporates symbolic abstraction but demonstrates only limited traceability between the analogue and the resulting architectural organisation. It therefore illustrates that the presence of symbolism alone is insufficient to satisfy the full requirements of the proposed I–A–T framework. For an analogy to function as a genuine design concept, its abstracted principles must remain demonstrably traceable throughout the architectural solution rather than being confined primarily to formal resemblance. The analogy of a 'squatting watchdog' for the design of a security building provides a simple but instructive illustration of the proposed Identification–Abstraction–Translation (I–A–T) framework. In this example, the designer does not select the dog merely because of its physical appearance but because of its recognised behavioural role as a vigilant guardian of territory. During the 'Identification' stage, the watchdog is chosen as the source domain because it embodies qualities such as continuous surveillance, territorial awareness, alertness, rapid response to intrusion, and protection of property. These behavioural characteristics are subsequently subjected to 'Abstraction', whereby the literal image of the squatting dog is discarded and only its transferable principles are retained. The designer therefore extracts architectural principles such as panoramic visibility, strategic positioning, unobstructed sightlines, immediate accessibility, territorial control, and psychological deterrence. In the 'Translation' stage, these abstracted principles are transformed into architectural decisions by locating the security building at the principal entrance, providing a 360-degree observation room, establishing clear visual control over access routes, integrating rapid circulation paths for security personnel, and incorporating surveillance technologies that enhance situational awareness. The completed building need not resemble a dog in either form or appearance because the analogy is expressed through operational performance rather than visual imitation. Conversely, a security post deliberately shaped as a squatting dog without demonstrating how the dog's behavioural attributes influence its planning, spatial organisation, or operational effectiveness would represent 'Identification followed by literal replication' rather than 'Identification–Abstraction–Translation'. Such a design would therefore correspond more closely to Broadbent's (1973) 'iconic design' than to genuine analogy-based concept generation. The example reinforces the central proposition of the I–A–T framework that an analogue should function as a source of transferable design logic rather than as an object for direct architectural reproduction. The domain-consistency test, illustrated in Table 2, therefore functions as a screening step that must be satisfied before the identification–abstraction–translation sequence proceeds: it asks not "is this a striking image?" but "does the functional, organisational, or performative logic of this design problem match the logic of the biological system being proposed as its analogy?" Where the answer is negative, biomimicry should not be adopted for that project, regardless of its visual or rhetorical appeal, and the designer should seek an alternative analogical domain whose logic is genuinely consistent with the problem at hand. This reframes biomimicry not as a stylistic movement available to any building type, but as a rigorously screened subclass within the broader analogical design tradition described in Sections 2 and 4 — one that must clear an additional consistency test before its source material is abstracted and translated into layout, spatial-relationship, or form concepts.

This is stated formally as Proposition 2: biomimicry functions as a valid design-concept driver only when the functional, organisational, or performative logic of the architectural problem is consistent with the functional logic of the biological system serving as the object of mimicry, and collapses into decorative, iconic reference where this consistency is absent.

Table 2: Illustrative application of the domain-consistency test using the Eastgate example

Domain-consistency question	Eastgate assessment
What is the architectural problem?	Thermal comfort and ventilation in a large commercial building with reduced cooling demand
What is the biological source?	Termite-mound environmental regulation
What is the biological logic?	Air exchange, thermal buffering and regulation through interconnected channels and material mass
Does this logic correspond to the architectural problem?	Yes; both concern regulating an occupied internal environment under changing external conditions
What principle is transferred?	Ventilation pathways, thermal storage, intake and exhaust logic
Is literal visual copying avoided?	Largely yes; the building is not shaped as a termite mound
Is the principle translated architecturally?	Yes; through ducts, thermal mass, atrium, façade shaping and exhaust chimneys

6. Implications for Studio Teaching

The framework developed above carries direct implications for the sequencing, exercises, and assessment criteria of architectural design studios.

First, analogy should be taught overtly, rather than left implicit in studio critique. Introducing Broadbent's taxonomy of design modes and the identification–abstraction–translation model explicitly in early design studios gives students a shared vocabulary for discussing how concepts are generated, and prevents the common confusion between analogic invention and iconic copying. Second, abstraction should be practised as a discrete skill before it is applied to a building brief. Basic-design exercises that require students to reduce a natural or pictorial source to its essential compositional logic — independent of any architectural programme — build the capacity for non-literal transfer that the translation stage subsequently depends upon (Ghom, 2017). Only after this capacity is established should applied exercises require students to carry an abstracted analogy into a full design brief. Third, applied studio exercises should explicitly require students to demonstrate traceability of their analogy across at least two of the three concept registers, even where only one register is fully resolved in the final design. This can be operationalised in the design brief itself, and tested directly in desk critique and jury review.

Fourth, where a project proposes biomimicry, the studio brief and assessment rubric should require students to articulate the domain-consistency justification explicitly — naming the functional, organisational, or performative logic of the design problem and demonstrating its consistency with the logic of the biological system invoked — before the biomimetic concept is credited as a valid design driver rather than as biophilic ornament.

Fifth, critique protocols should be recalibrated around three diagnostic questions rather than a single judgement of whether a concept exists: is the analogy legible? Has it been genuinely abstracted, rather than left as a literal image? And has it been translated with traceable consistency into the concept register or registers the project claims to address? This reframes studio critique from a subjective judgement of novelty toward a structured evaluation of process,

which is more teachable, more defensible in assessment, and more transferable across differing student aptitudes, consistent with the finding that structured guidance in analogical reasoning benefits novice designers most (Casakin & Goldschmidt, 2000).

7. Discussion

7.1 Contribution as a Conceptual Paper

As a conceptual paper in MacInnis's (2011) sense, this paper's contribution is the I–A–T model and the three propositions it generates, rather than a comprehensive synthesis of prior literature. Restated together, Proposition 1 holds that a valid design concept requires the identified analogy to remain traceable across the layout, spatial-relationship, and form concept registers; Proposition 2 holds that biomimicry is a valid design driver only where a domain-consistency test confirms that the architectural problem's logic matches the biological system's logic; and Proposition 3 holds that analogical design competence is trainable through explicit, staged instruction rather than an innate aptitude left to develop unassisted. Together, these propositions unify design-cognition research on analogy, the established taxonomy of layout, spatial-relationship, and form concepts, and the critical literature on biomimicry into a single, teachable procedural model, and they give studio instructors a concrete, defensible basis for distinguishing a genuine design concept from a superficial analogical gesture.

7.2 Agenda for Empirical Validation of P1–P3

P1 and P3 are directly testable through controlled studio-based experiments of the kind conducted by Casakin and Goldschmidt (1999, 2000) and Nazidizaji and colleagues, comparing design outcomes produced under explicit I–A–T instruction against outcomes produced under conventional, unstructured studio critique, and measuring traceability of the resulting concepts across the three registers. P2 is testable through comparative analysis of student or professional projects that do and do not satisfy the domain-consistency test, examining whether satisfying it predicts jury or critique evaluations of design quality.

Such research should also examine whether the propositions' effects are moderated by expertise, given existing evidence that novice and expert designers deploy analogy differently (Casakin, 2010), and whether the model performs consistently across differing cultural contexts of analogy, given that source domains for architectural analogy — whether drawn from local ecology, vernacular building culture, or regional narrative — are not culturally neutral.

7.3 Limitations and Moderating Factors

As with any conceptual contribution, this framework's limitations follow directly from its stated methodology (Section 3). The I–A–T model and the domain-consistency test are, by design, propositions rather than demonstrated findings, and their validation is deferred to the empirical agenda in Section 7.2 rather than resolved here. The literature engagement in Section 2 was selected purposively to warrant specific components of the model rather than to survey the field of design-cognition research exhaustively, and the illustrative cases used to demonstrate the domain-consistency test — the termite-mound/Eastgate analogy and the flower-petal counterexample — were chosen for their clarity, not because they constitute a representative sample of biomimetic practice. Finally, the framework does not yet specify how designer expertise or the cultural specificity of a given source domain might moderate the trainability claim (P3) or the applicability of the domain-consistency test (P2); these are identified as priorities for the empirical research the framework is intended to provoke, rather than settled by

the conceptual argument advanced here.

8. Conclusion

This paper has advanced a conceptual framework, not a systematic review, arguing that design-concept generation — though often treated in architectural education as a matter of individual talent — can be taught as a disciplined procedure grounded in analogical reasoning. The identification–abstraction–translation model operationalises this procedure, and its traceability requirement — that an identified analogy remain legible across the layout concept, spatial-relationship concept, and form concept, whichever registers a project develops — provides studio instructors with a concrete criterion for evaluating the validity of student concepts.

Biomimicry, properly understood, is not an independent stylistic category but a specialised and conditional subclass of analogical design, one that should be adopted only where a domain-consistency test confirms that the functional, organisational, or performative logic of the architectural problem matches the logic of the biological system proposed as its source.

Universities teaching architectural design would benefit from incorporating this framework explicitly into studio curricula, critique protocols, and assessment criteria, both to demystify concept generation for students and to raise the theoretical rigour with which biomimetic design is taught and evaluated. The three propositions advanced here — P1 on traceability, P2 on domain consistency, and P3 on the trainability of analogical competence — are offered as a concrete agenda for the controlled, studio-based empirical research needed to test and refine them.

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