Drawing as a Language in the Design Process: a Cognitive Bridge Between Thinking and Representation

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Abstract

The design process is inherently representational; drawing and similar tools reduce cognitive load and enable the generation, recording and reuse of ideas. This process supports the internal dialogue that fosters innovative solutions. Representations have both external forms, such as drawing and modelling, and internal forms, such as imagination and thought, while language is a crucial tool that guides the processes of thinking and doing. While verbal expressions convey abstract thoughts and provide insight into the problem, visual representations concretise abstract ideas. This study analyses the transitions between verbal and visual representational languages, examining how ideas are transformed into representations, what comes to the fore, and what is left behind in this process. The ways designers structure ideas, the gaps that occur in the transitions between representational languages , and the ways they cope with these gaps are revealed through an examination conducted through drawing and physical modelling. The study positions drawing as a bridge between languages, moving it beyond being a mere representational tool in the design process, and focuses on the role of drawing in framing, organising and translating design ideas, making it an indispensable component of the discovery process.

Keywords: design process, representations, verbal-visual, drawing, inter-language.

Introduction

Design is a complex process in which the designer expresses his thoughts, dreams and experiences in a concrete world. Representations play a critical role in this process, regardless of their form. For design to take shape, ideas must be externalised. Images designed in a person's mind cannot turn into a design unless they are externalised to a physical space or environment; in the context of design, this refers to the place where the design is realised. It is crucial to transfer ideas to an external environment quickly. There are several reasons for this. These are: especially in the early stages of design, ideas may be straightforward; since the mind works in a constant state of flux, the designer's ideas need to be transferred to external memory so that they are not lost; ideas may be vague and are tried to be clarified by transferring them to an external environment; the designer makes representations to make sense of his ideas or dreams or to be able to transform them into something different, to open his ideas to new possibilities. Schön defined the design process: "as a reflective conversation with the materials of a design situation" [Schön 1992, p. 133]. According to Harrison and Minneman [1996], the materials, objects or external design representations change the dynamics of idea generation and development as part of design communication [Brereton 2004].

Not all designers' objects are of a single type and can take various forms. They differ in terms of purpose, consistency and level of abstraction [Grignon 2000]. They can give a holistic and detailed expression of the designed 'thing', or

they can be partial; they can only draw attention to selected elements [Goldschmidt 2004; Herbert 1988]. In this context, representations of design refer to the various media and methods used to transfer design from the mental to the physical.
During the design process, especially during design education, students use verbal representations to convey and organise their thoughts and visual representations such as diagrams, drawings, mock-ups and models to explain these ideas. Therefore, it is said that design includes both verbal and visual expressions. The design process necessarily translates meanings between these two languages [Tomes et al. 1998].
Understanding or investigating how ideas are created, matured, evaluated, developed, modified or sustained in the context of representations is necessary. Drawing enables designers to engage in a reflective dialogue with themselves and other representations, like Schön's [Schön 1983] concept of 'reflection in action', where visual representation becomes an active site of knowledge production rather than mere documentation. This study examines drawing as an interlanguage that mediates between verbal thought, visualisation and physical modelling and positions it as an active agent in design cognition.

Integration of visual and verbal representational languages

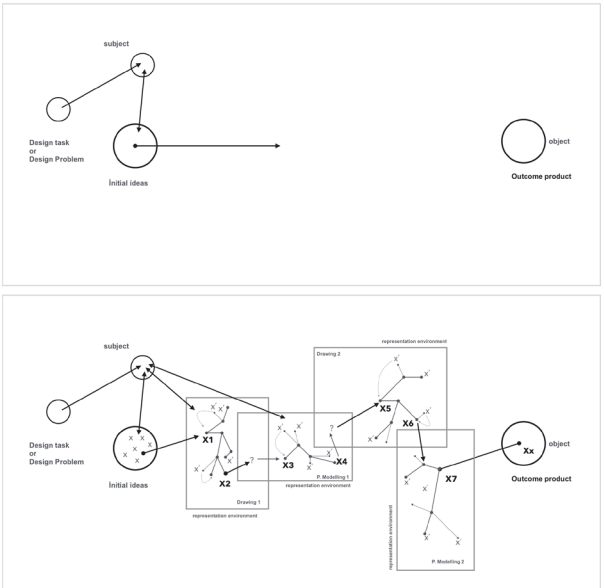
Architects use language extensively throughout the design process [Avidan, Goldschmidt 2013]. In the design process, the integration of verbal and visual representations creates a stronger narrative [Barelkowski 2010] in designers' practical expression of their dreams to themselves and others. Verbal representations illuminate the 'how' of designs, encouraging future actions, problems and possibilities for solutions; visual representations, on the other hand, enable ideas to gain a physical dimension. Transitions between verbal and visual representations expand designers' cognitive flexibility [Dong 2007; Özçam 2022].
However, the interaction between verbal and visual languages is essential for transforming and bringing ideas to a conclusion. Internal ideas and the final representation can often differ from the original image. When this idea starts to be expressed in verbal and visual representation languages, a transition, change, or translation process begins [Tsow, Beamer 1987; Rykwert 1998]. In such cases, there is a lack of understanding of how designers think and act (creating representations such as drawings and models) to explore possibilities to move forward [Cash et al. 2023].
The most crucial relationship between verbal and visual languages is that they simultaneously support each other and work to strengthen expression. As Pellegrino [1995] stated, there are forms of relationship between visual form and existential form (imaginary and representation), such as difference and similarity, closeness and distance, importance and silence (we can say explicit or implicit) [Cikis, Ek 2010]. In this interaction between verbal and visual languages, drawing serves as a bridge that provides an iterative back-and-forth movement between internalisation and externalisation, serving as both a means of production and interpretation.

Inter-language relationships in the design process: verbal expression –drawing– model relationship

In the design process, there is a complex but complementary relationship between verbal expression, which allows designers to explain their ideas with words and concepts, and visualisation, which enables the ideas to become concrete [Woo 2021]. Design is a process that inherently involves both visual and verbal expressions and the translation processes between these languages; in other words, design is a process that transforms one set of representational languages into another [Goel 1995]. In this process, it is thought that there are creative gaps in the transitions between languages [Bolt 2004].
In the design process, verbal language has functions such as shaping, organising thoughts, and allowing the designers to share their ideas with themselves and others [Lee et al. 2019]. Therefore, they are tools to reach the designer's mind. Verbal expressions form the basis of the abstract ideas' designers want to convey. The interaction between verbal and visual languages in the design process creates a cognitive bridge [Fan et al. 2023]. Therefore, the design process involves the serial production of a series of representations until a 'satisfactory' end is reached [Goldschmidt 2004]. There is an iterative movement between thinking (verbalisation), drawing, and physical models. This movement is a dynamic back-and-forth loop of representational changes. The relationship between verbalisation –Drawing– physical model is reflective and contains transitional relations (fig. 1). Drawing is emphasised in these relations

as both a reflector of thoughts and a flexible tool that supports and interprets production.
A design process involves creating an image of an imagined object or artefact through expressions and representations. Since each representation may contain a seed of the final product, it carries the meaning of something that develops upon them but is not yet fully present in the intended state [Binder et al. 2011]. Designers objectify and manipulate each seed by producing various representations of the design. The main work of the design process is to transform these representations until the final product is obtained through these expressions.
Designers use various visual languages, including narratives, graphics, drawings, and 3D objects, to facilitate creative discoveries [Porter 2004]. Understanding the relationships between these languages resembles a translation process, as transferring architectural representations is not always straightforward and may not align perfectly with the primary source [Rodeia 2019]. Designers' choice of language depends on their focus and desired effects, with architects primarily using drawings and models in the early design stages [Grignon 2000].
Research emphasises the importance of visual thinking, mainly through drawing and visual tools, in solving design problems [Arnheim 1969; McKim 1997; Goldschmidt 1991; Goel 1995]. Drawing is vital across disciplines [Krippendorf 2005; Schön, Wiggins 1992] and facilitates reflective conversations and collaboration [Goldschmidt 1991; Van der Lugt 2005]. It enables designers to experiment and reinterpret their work [Schön, Wiggins 1992; Oxman 1997]. Models like 'seeing as' and 'seeing that' [Goldschmidt 1994] and the 'imagine –see– draw' cycle [McKim 1997] illustrate this process. Drawing serves as an effective tool to connect the past and the future, helping with problem-solving and expressing ideas.
Drawing is a crucial tool that reflects designers' intellectual and physical experiences and creative processes [Magalhães 2014]. Like drawings, models range in their interpretability –from rough drafts to production-ready forms [Hornecker 2007]. While it is commonly thought that models, including digital ones, primarily 'communicate' design ideas rather than 'produce' them [Starkey 2007; Evans 1986], modern design studios showcase models that can be as fluid and changeable as sketches. Design practice integrates various physical and digital materials, organising representations through imagination and realisation. Producing, transforming and evaluating representations [Visser 2010] is carried out to emphasise different aspects of the design by switching between various levels of abstraction, different environments, scales and materials to expand the design space and narrow the concepts [Binder et al. 2011].
The objects of design (drawing and model) not only concretise the design but also shape it by activating internal processes. Drawing is a field where mental processes and imagination become visible and gain meaning, in addition to being a representation of design. For Song [2011], drawings are a tool through which designers express their imagination, especially during problem structuring and solving in the early stages of the design process. Therefore, within the scope of this study, drawing is considered to assume the role of a bridge between design thinking and the physical model. While drawing allows the designer to concretise their ideas on the one hand, it also provides a basis for transforming these ideas into a physical form on the other. Drawing is an intermediate form between abstract thoughts and concrete implementation. However, this gap also brings difficulties and opportunities for designers when

Fig. 1. Creation of representations, decisions, and transitions until a satisfactory conclusion is achieved in the design process.



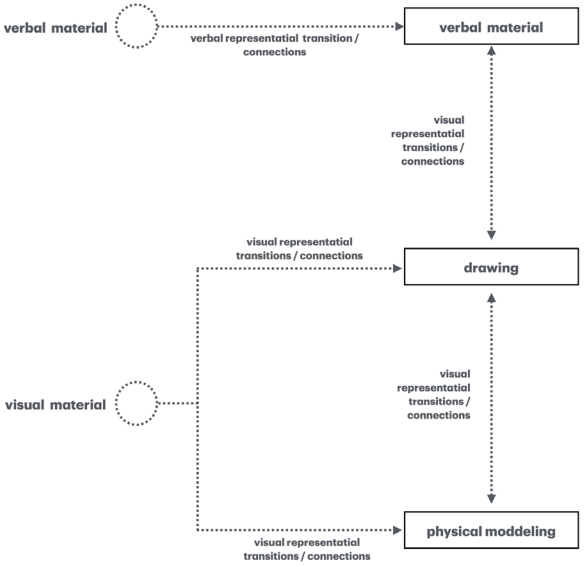
transitioning between drawing and modelling. While drawing is the first intellectual step in the design process, a model is a physical representation of the design. While drawing provides a tool for concretising abstract ideas, a model shows how these ideas will come to life in the real world. Drawing also serves as an active site of meaning-making, like a linguistic translation process between verbal and visual cognition. Drawing acts as a visualisation tool and a linguistic interpreter, allowing designers to reframe and develop the ideas they want to build. Students' iterative construction through drawing suggests that it functions as a 'meta-language' – a flexible, evolving system through which ideas are translated, questioned, and transformed.

Transitions between verbal expression, drawing and physical model in the design process

Design begins with an idea [Gonçalves, Cash 2021]. Verbal language helps clarify the designer's thoughts, addressing ambiguities and detailing concepts. Studies highlight the impact of verbal expression on visual representation [Avidan, Goldschmidt 2013; Cikis, Ek 2010]. A design task study using the think-aloud method captured designers' initial thoughts to explore their transition between verbal and visual expressions, particularly the role of drawing as a bridge in this process.
The research focused on developing ideas through iterative cycles of drawing and modelling, assessing their progression or decline. A field study involving six architecture students included a two-stage design task in which participants verbally expressed their thoughts and a written report task at the end of the process. These sessions were recorded, documented, and analysed by correlating drawing and physical modelling actions with verbal expressions. Although the sample size is limited, it allows for a unique qualitative analysis of individual design processes, and insights into cognitive shifts and inter-representational movements in design thinking provide a foundation for future studies.
Design Task Phase 1: "Something Flowing from a Crack in the Mountain".
Design Task Phase 2: "What if Something Flowing from a Crack in the Mountain Becomes an Art Gallery?"
Task for stage 3: Students were asked to prepare a report by considering the entire process and reviewing the drawings and models they had made.

Schön's [Schön 1983] 'reflective practitioner' paradigm is vital for understanding and examining the design process. This paradigm has two important reflection concepts. One of these is 'Reflection in action', which aims to understand the relationship and cognitive activities between the thoughts and actions of designers throughout the process. The other is 'Reflection on action', which reconstructs the designer's thought processes on that action after the action is completed. Cowan [2006] adds the concept of 'Reflection for action', which determines future intentions, as a third process. Within the scope of the field study, students explained their initial ideas before the action (reflection for action). Then, they explained how they drew and modelled with a loud speech protocol (reflection in action) accompanied by a camera recording. Finally, at the end of the process, they wrote a report explaining what they thought and did (reflection on action).
To understand and capture the complex transitions in the design process, Paivio's [1986] dual coding theory was expanded into a tripartite framework of verbal expression –drawin– physical modelling (fig. 2).

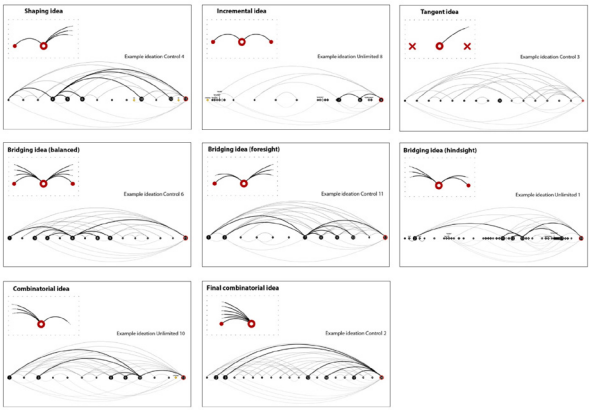
Fig. 2. Verbal –Drawing– Model transition and connections relationship diagram.

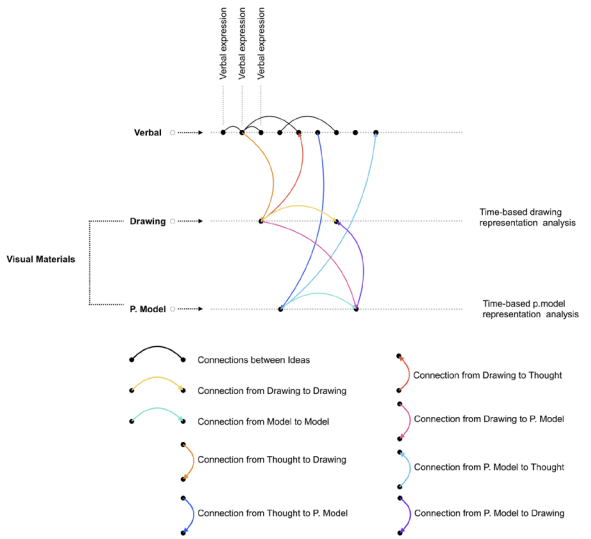


Gonçalves and Cash [Cash 2021] conducted an analysis study based on the s binary coding system to reveal the connections between ideas. Eight archetypes of connections between ideas were used in this study, and these eight archetypes are Shaping Ideas, where early ideas affect later idea formation with a few backlinks; Incremental Ideas, which are closely tied to the previous concept and progress from one idea to another with minor changes, Tangent Ideas, which lack connections to previous and future ideas, ideas with many connections, connecting multiple front and backlinks, Bridging Ideas, which have three different variations: Balanced, where front and backlinks are similar, Foresight, which has many front links, Hindsight, which has many backlinks, Combinatorial Ideas, which connect many previous ideas and create convergence before creating more ideas, and ideas that emerge late in the session and produce a final concept based on the combination of previous ideas with many backlinks (fig. 3).
Gonçalves and Cash's [Cash 2021] qualitative connection cluster analysis was considered a triple system of verbal – drawing and model within the scope of this study. The students' routes were extracted with the nodes and bridges in the verbal-verbal transitions between the ideas themselves in the verbal-visual transitions between verbal-drawing and verbal-physical model, as well as visual-visual transitions between drawing and physical model.
The students' protocols were organised into sentences using a temporal system and linked to the verbal sentences where drawing and modelling began. The study examined the transitions between verbal expressions, drawings, and models through Linkography's forward and backward connections. By framing the connections of how ideas are created, connected, evaluated, judged and synthesised [Gonçalves, Cash 2021], verbal-verbal connections were represented by associating them with drawing and model representation connections. Within the scope of the study, how designers switch between verbal-visual and visual-visual languages is discussed, and what role drawing plays in this process is discussed. The formation, development, and evaluation of ideas in the iterative cycle between thinking –drawing– and physical models were examined about the progress, changes, and transitions in representations.
Based on the theoretical synthesis of Paivios [1986] dual coding theory and the Gonçalves and Cash's [Gonçalves, Cash 2021] typology of idea connections, this study proposes a new analytical model to examine transitions in student design cognition. The model extends the binary

Fig. 3. Eight archetypes of ideational connections [Gonçalves, Cash 2021, p. 12].

Fig. 4. Cognitive mapping of reflective transitions in design: integrating binary coding yheory and connection typologies through forms of representation.



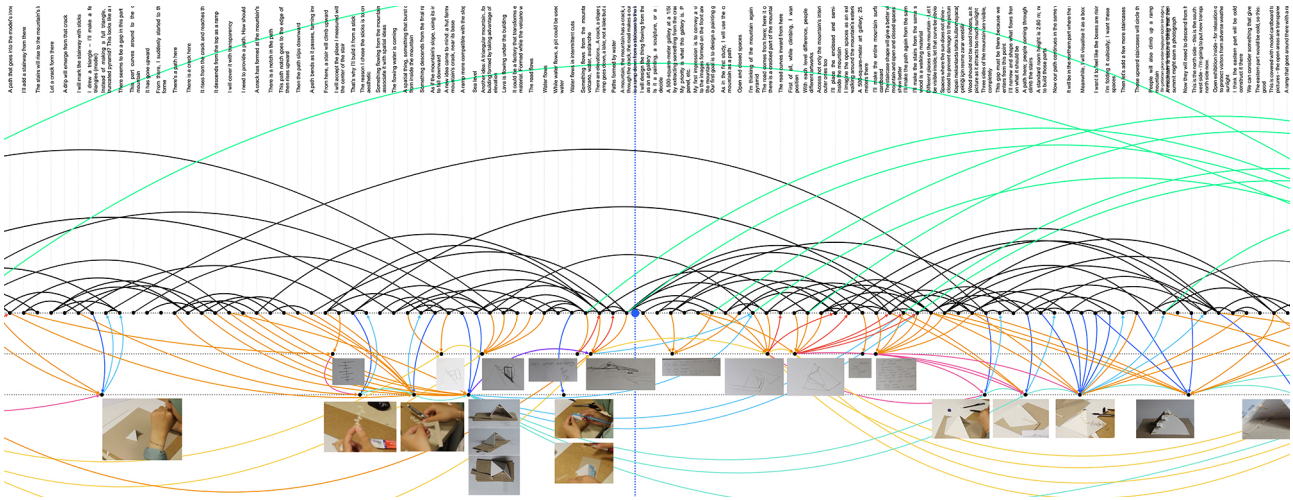


structure into a tripartite framework composed of verbal expression, drawing, and physical modelling. Within this framework, verbal-verbal, verbal-visual, and visual-visual transitions were mapped using Linkography-inspired representations of forward and backward connections.
This tripartite model allows the mapping of cognitive movements between these three forms of expression (fig. 4). Drawing is not only a visual representation but is also seen as an interpretive or communicative tool that provides transitions and translations between verbal thought and physical expression.

Evaluation

Subject 1 began the drawing process after generating ideas, creating a drawing and taking notes with each selection. Subject 1 initial organic mountain evolved from a triangular to a square structure. The second triangular mountain and road significantly influenced the students' concept and model production, resulting in a drawing with more nodes and foresight bridging. When considering how to create something (stairs), the student quickly turned to drawing and produced a model based on that. After completing the first stage, subject 1 drew the model and adapted his second stage drawing to fit the task. It is seen that the student used the students' drawings mainly before starting to produce the model by developing and maturing the students' ideas and reaching a decision with them. Subject 1 used drawings to refine uncertainties before transitioning to the model. When the entire model process was over, the student used it as a second language to describe the gaps his existing model could not describe (transparent spaces facing south, the interior space being spacious, etc.) or, in other words, expressions (fig. 5).
Subject 2 quickly translated his initial ideas into a drawing, which guided the subject's modelling process. As the subject's concepts evolved, he made detailed decisions, such as placing a crack in the design. At the end of modelling, the subject created additional drawings, including top-view perspectives, to capture ideas not fully conveyed in the subject's initial perspective drawings. While colouring to enhance the subject's work, the subject experienced an A!Ha! moment, leading to a new concept (Flowing image) that clarified the subject's ideas. In the next stage, the subject created drawings to explore the model's interior and spaces (open, semi-open, and closed), introducing the axis concept. The subject concluded by reviewing and emphasising his drawings (fig. 6).

Fig. 5. Analysis of subject 1 related to verbal-drawing-physical model transitions.



Subject 3 did not have his first ideas in mind at first. However, the only idea that came to the subject's mind, "there may be a crack in the cave depending on the size of the mountain", was first realised with a digital drawing. Subject 3 then reproduced the same drawing by hand. This triggered more thinking. Subject 3 wanted to show the circular form in the subject's first drawing in 3 dimensions. However, with the physical model materials the subject added later, he had a 3-dimensional production that moved in a different direction. Since the student could not make time, the subject continued with the student's physical model to the second stage. New ideas emerged while creating the model, and the student supported these new ideas with a few detailed drawings at the end of the process. We can see that this drawing formed a balanced bridge node between the thought and the model (fig. 7).

Subject 4, unlike the other subjects, started by trying to express his first ideas with a model. However, since the modelling process was long, the student drew to express the vague ideas that came to mind (for the vague image of a 'flowing thing' rather than a mountain). The student first expressed this with a drawing by seeing a 'new thing' in the student's physical model (mountain topography) and focused on the student's ideas. Then, the subject shaped his model accordingly. When a new idea (mountain topography) came to mind during the process, the subject expressed it by drawing. However, the subject continued by making choices in the student's drawings ('I will continue with this for now' (field notes, Subject 4). In the second stage, the student continued the subject's ideas with the model, but it was seen that he drew to make decisions about vague 'spaces' such as a 'flowing thing'. When the student's drawings were examined, it was seen in the subject's first ideas: A mountain with a steep slope, a moving flowing thing gushing out of rectangles. The linguistic equivalents of these expressions can be read in his drawing, but it is also seen that the subject has added other small mountain additions to his drawing. In addition, although the statement "mountains are not important to me", what flows is more important; it is seen that the subject thinks about the mountain form the most in his drawings (fig. 8).

Subject 5 starts the study by taking notes and drawing. It is seen that the student adds ideas to the same drawing by drawing them in his drawings. It is possible to read a similar transfer of the subject's first ideational expressions through the language of drawing. In addition, the student records and thinks about the subject's research by drawing and taking notes. There are variations regarding cracks in the subject's first drawing, and in the second drawing, the students decide on the idea that 'the crack is an opening

Fig. 6. Analysis of Subject 2 related to verbal-drawing-physicality model transitions.

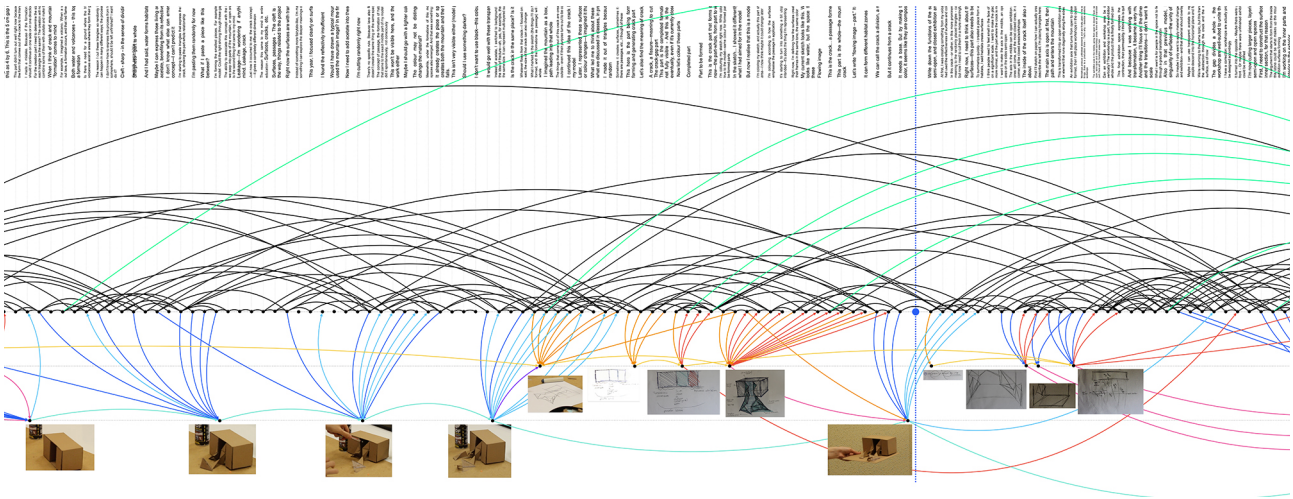
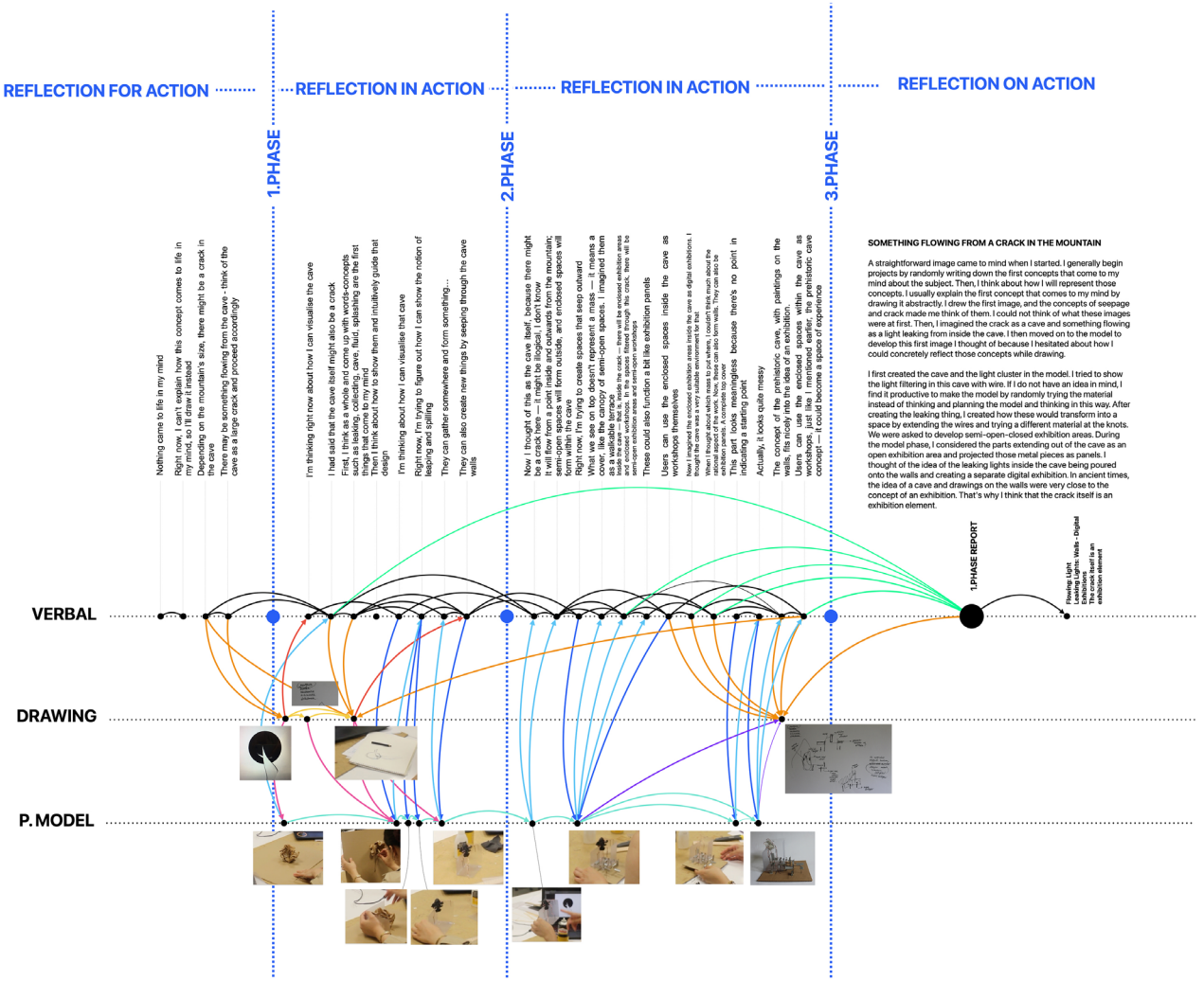


Fig. 7: Analysis of Subject 3 related to verbal-drawing-physical model transitions.



where a paraglider is made'. However, although there are more realistic mountain and crack expressions with organic lines, the student has transformed this organic drawing language into a model language in the form of a rectangular prism in the model. At the end of the model process, the subject added textural elements such as rope to his drawing and clarified the subject's concepts in the drawing. At some point, a new idea ('cave') came to the subject's mind. Although he expressed it with a model, he did not reflect it in the drawing. In the second stage, subject 5 had a similar solution to the first. The subject used the drawing paper to take more notes and made diagrammatic drawings while solving the locations of the spaces (semi-open spaces inside the open space, open spaces outside, etc.). In addition, Subject 5's gaining knowledge and inspiration through the research process and expressing them as a visual language with drawing and writing is an effort to show the information he acquired in another language (fig. 9).
Subject 6 tried to deepen the subject's first ideas and between them by using drawing paper to take notes and draw. In the drawings, the student attempted to produce a physical model consisting of a crack and surfaces that should be at a point but with an empty interior, even if the subject used organic form in solid forms. In the first stage, the student used drawing and taking notes to brainstorm for a long time. It is seen that each drawing of the student bridges. However, the drawing the subject drew towards the end of the first stage is an image that appeared in the subject's mind during the model making. This image has many connections, and he reproduced it as a drawing by giving it meaning from the model. At the end of the process, the student drew a section to complete the parts where the model language was inadequate (fig. 10).

Conclusions: Drawing As A(N) – (Inter)Language

This study shows that drawing has a vital place in interlingual translation. Acting as a balancing tool between languages, drawing exists in a space of density and ambiguity, revealing focal points in the chaos of ideas. In the chaos of ideas, it shows the focal points in the mind. On the other hand,

Fig. 8. Analysis of subject 4 related to verb verbal-drawing-physical transitions.

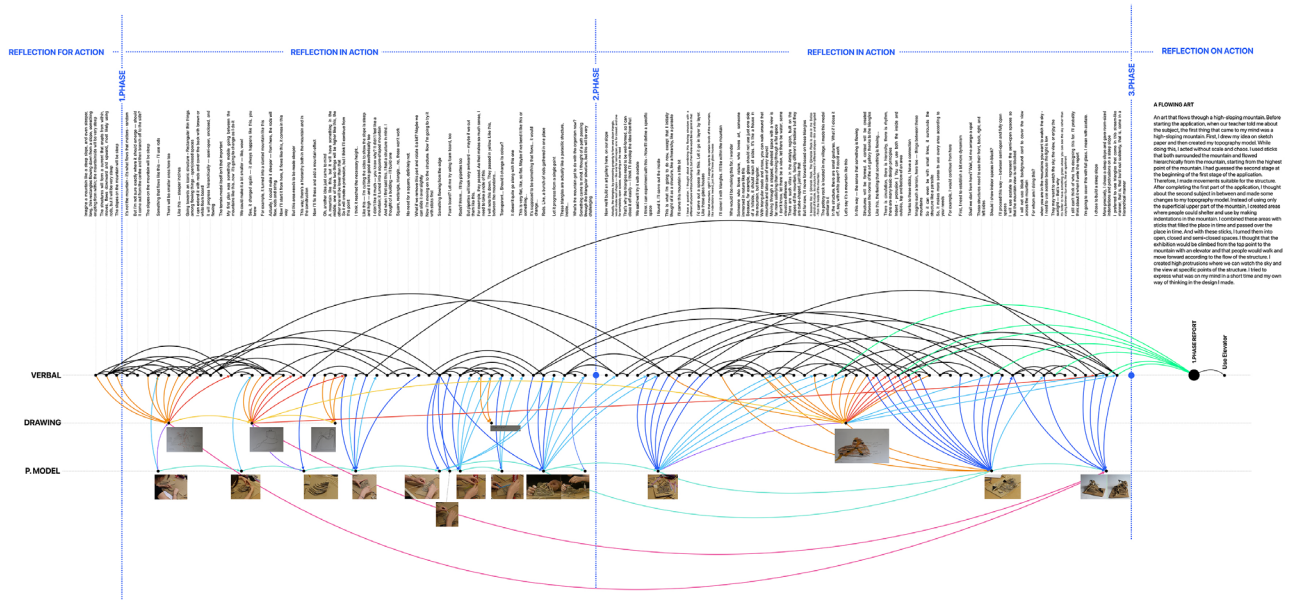
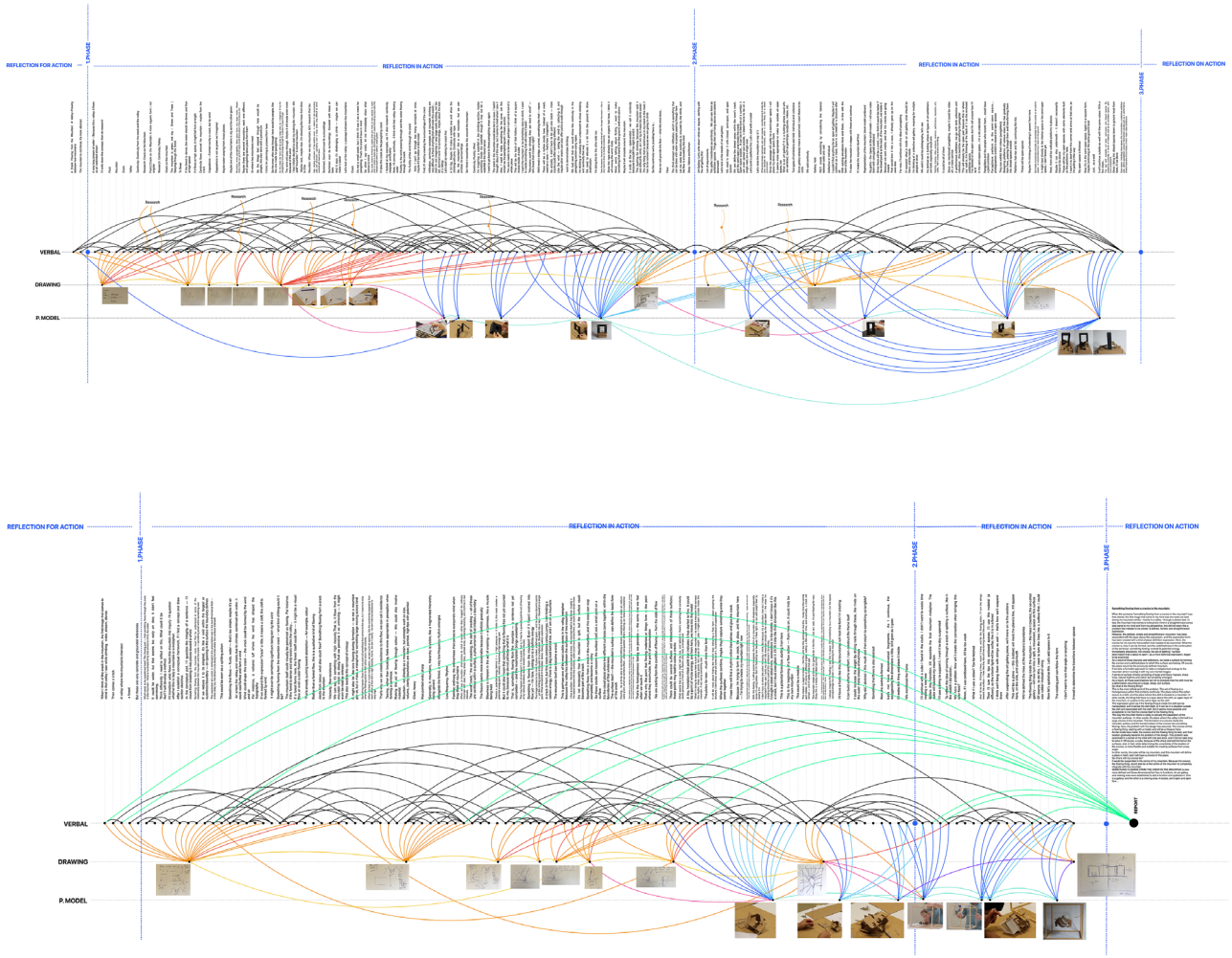


Fig. 9. Analysis of Subject 5 related to verbal-drawing-physical model transitions.

Fig. 10. Subject 6's analysis of verbal-drawing-physical model transitions.



it interprets what the model cannot say. In this reflective dialogue process, embodied expressions participate in reinterpretation, as various researchers noted in the previous sections. This is a reinterpretation both by the designer and others. Just like Umberto Eco's [1992] concept of 'Opera Aperta' (a text or a work does not have a fixed meaning; the reader or the viewer reproduces it), drawings can be reinterpreted and reproduced like languages (just like each student interprets the thing flowing from the crack in the mountain differently, or if we break it down into its building blocks, they interpret the 'mountain' or the 'crack' differently). While language produces different meanings with the words in its context, drawing also produces meaning with its visual components and participates in a dynamic meaning-production process with both the designer and the viewer. This study highlights the role of nodal points in these transitions. These transitions show how designers generate new meanings as they shift between different representational languages. Drawing is also a cognitive activity that activates thought processes and bridges internal and external representations. Modelling tests these ideas or two-dimensional linear expressions in a more concrete and physical environment. In this way, it can be said that the gaps between ideas or the gaps formed during the transition to the model are integrated by being supported by drawings. In the future, a more in-depth investigation of these transitions, how designers manage these transitions, the dynamics of the process and how drawing initiates a translation process will help develop new strategies to understand designers' creative processes and the importance of emphasising the reflectivity of drawing in design education. This study positions drawing as more than a representational tool; it is an active interpretive language that shapes design cognition. Drawing can be seen as an open system that allows for reinterpretation and transformation, like a language (text-artwork), where meaning is produced through interaction. This research will support future studies on how the language of drawing can shape new pedagogical strategies in architectural education by highlighting nuanced cognitive transitions across the verbal, visual, and physical domains.

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