

DIAGRAMS IN CREATIVITY

Anders Hermund

The Royal Danish Academy of Fine Arts, Schools of Architecture, Design and Conservation,
School of Architecture

IBD - Institute of Architecture and Design

Philip de Langes Allé 10

DK-1435 Copenhagen K

Denmark

e-mail: anders.hermund@kadk.dk

telephone: +45 4170 1896

Abstract

Through the use of a diagrammatic method it seems possible to support a both intuitive and controlled framework for creation of artistic work using 3D printing technology in combination with artistic sensibility. The paper investigates to what extend such a method can be used to evaluate the outcome of a given artistic situation, with the intent to approach the essential needs in artistic creation. The specific diagrammatic methodology is fundamentally inspired by and further elaborated from C. S. Peirce's semiotic system consisting of interrelated signs, wherein the diagram holds a very special position in the semiotic reasoning process. Viewing the creation of art pieces through the specific diagrammatic approach, indicates that, in the given case, it can be possible to organize the process of creation according to a diagrammatic system, and that this system is flexible enough to allow for an artistic sensitivity and unpredictability as a main driver and parameter. Using the Peirce inspired diagrammatic approach can be useful as a framework for understanding the creation of art on a crossbreed platform involving both traditional skills, artistic inspiration, and newest technologies, such as 3D printing.

Keywords: *Diagram; Method; 3D print; Artwork*

1. Introduction

The question of how artists work with art can be answered in countless ways. It is possible to consider the way you work, and record how. The question of why the work is performed specifically in this way, and not in a different way, is a much more complex issue because it requires a delving deeper down below the layers and processes that underlie the design. The mental thinking underlying a given work of art is thus a significant factor in order to raise awareness of the opportunities and obstacles this means in practice. How does this affect the way we can reflect on the artistic result created? Art can be understood as an interaction between artist and other actors as well as interaction with technology. That tools available for artists are becoming more and more digital is a result of development in the rest

of society. That has resulted in the current case study of own artistic production of sculptures using 3D print technology, as a diagrammatic artistic methodology.

2. Diagrams

The diagram is one of the architect's most important tools. But it is also a broad concept ranging from logic diagrams and flow charts to architectural plans and sections and much more abstract ideas about how substances are relationally connected in the world we live in. Within semiotics, the diagram plays a significant role. Semiotics from the Greek σημειωτικός, semeiotikos, can be translated 'sign interpreter'. It comes from σήμα, sema, the Greek word for 'signs'. Semiotics is therefore the science of signs. Under the premise that everything that 'makes sense' is signs, semiotics can be used for analysis of a vast amount of words, actions, myths and all other meaningful sign systems, including works of art and artistic methodology.

2.1 The Semiotic Diagram

Charles Sanders Peirce (1839-1914) builds his very extensive writings about numerous topics related mainly to logic and philosophy of science, semiotics and mathematics, but also subjects such as aesthetics and metaphysics. He is also considered the main contributor to pragmatism. Peirce's thinking contains a constituent fascination of triads. Being able to divide and define concepts from tri-partitions is fundamental in several Peircean contexts. The most basic of tri-partitions is his classification of phenomena, which, in this way, can be understood in either Firstness, Secondness or Thirdness. The understanding of this becomes the starting point for his semiotics, and is therefore a very important distinction. Firstness is simple and elemental, potential, not real. The Secondness is existence. A realization of the Firstness' quality in quantity. If Firstness is feeling, Secondness is experience. Thirdness is the relation between Firstness and Secondness; it relates quality and quantity. Habits, laws and science belong here. The concretization of Thirdness realizes a given phenomenon from the Firstness universe of possibilities associated with a Secondness amount of events. Firstness is equivalent to the predicate, while Secondness is the subject and Thirdness the connection between the two [1].

In his semiotic system, Peirce uses the Firstness, Secondness, Thirdness trichotomy as a general principle for classification of the triads of signs, of which the most famous is Icon, Index, Symbol.

As shown (table 1) the diagram appears here as a particular type of icon, a hypoicon. Since it is an icon, it is representing its object through likeness. While the other two hypoicons, image and metaphor, are representing their objects through likeness via simple qualities and likeness through parallel to something else respectively, the diagram represents the object by structural similarity, through relationships between different parts. A relation based icon, supported by conventions [2].

Table 1 - Peircean categories and tricotomies

Firstness (idea, possibility)	Secondness (the existing)	Thirdness (thought process)
<i>The triadic relation</i>		
Sign (representamen) (The sign itself)	Object (semiotic object) (The sign's subject matter)	Interpretant (interpretant sign) (The sign's meaning)
<i>The phenomenological category of the sign itself</i>		
I. Qualisign (tone/potisign) (quality, possibility, a "first")	Sinsign (token/actisign) (reaction, resistance, a "second")	Legisign (type/famisign) (habit, rule, a "third")
<i>The different ways in which the sign refers to its object</i>		
II. Icon	Index	Symbol
Hypoicons { Image Firstness Diagram Secondness Metaphor Thirdness	(denotes its object by virtue of an actual connection)	(denotes its object by virtue of the fact that it will be interpreted to do so)
<i>That which the interpretant represents to be the sign's way of referring to its object - (relation til interpretant)</i>		
III. Rheme (represents object in respect of quality)	Dicisign (represents object in respect of fact)	Argument (represents object in respect of law)
		Simple arguments { Abduction Firstness Deduction Secondness Induction Thirdness

Source: Author's diagram, after C. S. Peirce

Frederik Stjernfelt describes in his doctoral thesis Diagrammatology [3] how the diagram in Peirce plays a central role, and can be spread out to a quite extensive operational tool for mental experiments and reasoning. A clean diagram, understood as a diagram not yet pointing to a specific situation or a specific physical context or content requires initially a rule from which it can be understood. An example would be this sinsign → which may be perceived as acting in different ways. Its occurrence could act as a connecting link, but could also show an effect, a direction, or other, depending on the rule, which is included for an understanding of the diagram. The rule is a symbol. Already a clean diagram without reference to anything specific is therefore an icon that is controlled by a symbol or a symbolic

rule. The symbols play a dual role for the diagram's operability, as it is by virtue of exactly a symbol that the diagram may act like interpreter for the given phenomenon referred to. The icon lets the diagram as an iconic legisign, operate within a set of rules and then predict something about that object which the symbol refers to. If e.g. an (iconic) arrow on a piece of paper is perceived (symbolic) as a direction, this can also be interpreting symbol for a North arrow and thereby diagrammatically show the direction to the north, for example, a on a map or an architectural drawing [3]. Such a diagram that includes some sort of relation to something (a possibility) in the world, are called empirical diagrams, in contrast to the pure mathematical diagrams that do not have these references, or relationships.

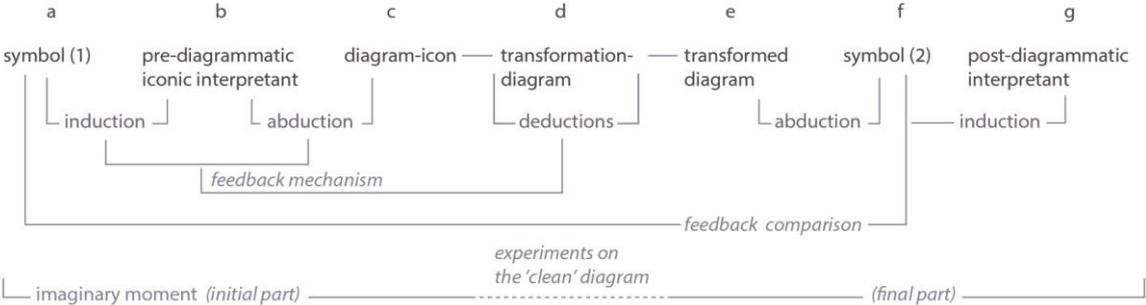
2.1.1 Experiments on the diagram

Being able to conduct experiments on a diagram requires of course the presence of this diagram, which is provided as part of a process involving several ways to draw inferences. In one example, regarding the design of a bridge, this stepwise process can be outlined [3]. The first step in this process is to draw a diagram showing the conceivable bridge construction which then is combined with a symbolic framework to establish an understanding - an 'initial symbolic interpretant', for example in the form of the relevant equations for calculation of the carrying capacity of the bridge. The bridge at this point is said to be represented by a symbol, and the interpretant is a pre-diagrammatic icon. These two together form a suggestion to how the bridge might seem, and meet the requirements there is to it. What matters is that this proposal offers the potential for transformation, so experiments can be performed on the diagram.

This initial proposal shows, according to Peirce [4], that there is both activity and curiosity present in the interpretant, which is a mixture that will normally lead to experimentation. This deductive experimentation function in accordance with the rules set in the diagram, derived from previous inductions (e.g. gravity as important for the calculation of the bridge's carrying capacity). These can be traced in part to a general assumption of the bridge by virtue of its use for cars (and not for atoms or planets) and the purely formal rules inherent in the equations with variables that are included in the diagram. Secondly, they can be traced to their individual requirements for logical consistency, independent of whether they are used in conjunction with a bridge. A third source of rules for conducting experiments is the intention of the diagram – i.e. why it has been created. In the example of the bridge, it will be the carrying capacity, which must be guaranteed, and thus becomes a motivation for experiments. These rules allow that the diagram is transformed through experimentation, and

the bridge design can be adjusted until it is working as intended in terms of carrying capacity and so on. The transformation-diagram becomes the transformed diagram, which in a way was contained from the beginning.

Table 2 - The structure of the diagrammatic reasoning with feedback mechanisms and relationships to forms of inference and the imaginary moment.



Source: Author’s diagram – inspired by Stjernfelt [3].

Here the concept of abduction must be introduced in the diagrammatic reasoning. The diagram operates deductively with origins in earlier inductions. However, there is another type of inference involved in the diagrammatic reasoning, namely abduction, an addition to the two other well-known forms of reasoning, deduction and induction. Together they form another triad: abduction (Firstness), deduction (Secondness) and induction (Thirdness). Abduction is kind of an educated guess that, by examining a number of facts and permitting them to propose a theory of correlation, can lead to a hypothesis. On a general level, it can be said that the abduction suggests how a given phenomenon can be formalized and then follow the deductive diagrammatic phase after which a final inductive study compares the transformed diagram with the given phenomenon in a conclusion. However, there is an intricate correlation between abduction and induction in the diagrammatic reasoning. With this in mind, the above explanation is further developed. From the inductively based data about the symbol pre-diagrammatic interpretant, abductive guesses are used to select the properties that will be sufficient to define a more formalized diagram. This is a feedback mechanism between the two inferences constantly trying to align the starting point with its diagram. The feedback mechanism also takes part in the next stage of performing deductive experiments on the diagram. The experiments carried out according to a constrained syntax for manipulation by identification of the diagram-icon with the properties of the object and the intention with which manipulation is carried out, creates opportunities for manipulation on the diagram itself, now understood as legisign. After experimentation and manipulation of the diagram, a possible symbolic understanding of the transformed diagram is created by

abduction. Finally, this second symbol can be compared inductively with the empirical information in the first interpretant. This is where it can be determined whether the diagram works in relation to the intention with which it was established (table 2).

2.1.2 The imaginary moment

When a diagram in this manner is established for experimental purposes, it appears as an icon, but intrinsically related to the symbols that interpret it. It is not a pure icon however, but a hypoicon, which can even be difficult to discern from its object. The ‘imaginary moment’ occurs just at the moment when the diagram appears to be the object itself, and not its representation. This happens by the contemplation of icons in general (such as art works), and with regard to diagrams, it is an important part of being able to define the rules by which to experiment on the diagram. In the first phases of the diagrammatic reasoning, intuition appears as a major factor. By virtue of abduction there is a guess to a link between symbol and diagram-icon, which applies also when the transformed diagram must be evaluated in a symbolic reading. This shows at once the many possibilities for using the diagram, but also a possible source of fallacies, because a certain bias about the object can blur the experiments. Creating a virtual division of the imaginary moment, a clean diagrammatic phase in which the diagram appears as a clean iconic legisign can be ensured, and distracting intuitions are prevented from affecting the outcome. This requires, however, an important subsequent comparison of the two symbols, in order to ascertain whether the diagram works.

3. Case Analysis of 3d Printed Sculptures

The 3D printed sculptures used as a case for a diagrammatical analysis in this paper have all been created software wise using Rhinoceros NURBS 3D modelling software and equipment wise using PLA plastic in various colors in a Flashforge Creator Pro 3D printer. In the following sections, the process of creation will be analyzed utilizing the diagrammatic reasoning introduced.

3.1 Diagrammatic Reasoning of Printed Sculptures

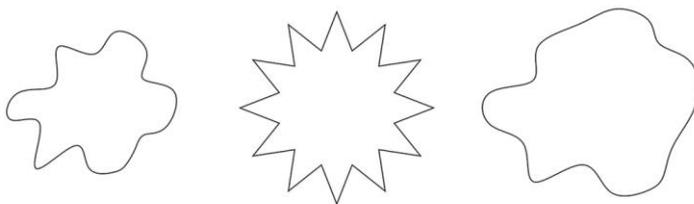
Using the diagrammatic reasoning as exemplified the process of creating a 3D printed sculptural work can be examined going through the stages from ‘a’ to ‘g’ (Table 2) adding a loop back through the transformation diagram in stage ‘d’, due to the specific nature of the case study here presented.

3.1.1 From symbol and pre-diagrammatic iconic interpretant to diagram-icon

It can be presumed that any creative process contains an amount of curiosity and activity, in order to qualify as a creative process, as a creative process without any activity is absurd or meaningless at best to discuss. The curiosity and activity towards an intention, in this case to create a specific piece of sculptural work, stems from an artistic inspiration. Since the origin of artistic inspiration, although very interesting in its own accord, is not the focus of this paper, it is enough to say here, that previous observations and experiences have invoked a specific intention in the artist to use the specific technology to create a specific expression. A desire to materialize the intangible in a meeting between the rigid and the sensitive, e.g. experiences from a lucid dream, inspired to combine modern technology and materials with an artistic sensibility, creating something both light, dreamlike, and at the same time hard and crystalized.

The first step is to draw a diagram 'a' showing a conceivable sculptural expression of soft and rigid. This, combined with a symbolic framework based on the induction of knowledge of the constraints and possibilities of the software modeller, the special PLA material, and the 3D printer technology, results in a pre-diagrammatic iconic interpretant 'b' (Table 2) as a first understanding of a sketch (figure 1).

Figure 1 - First steps of the diagrammatic reasoning based on inductive relation between the symbol and the pre-diagrammatic iconic interpretant.

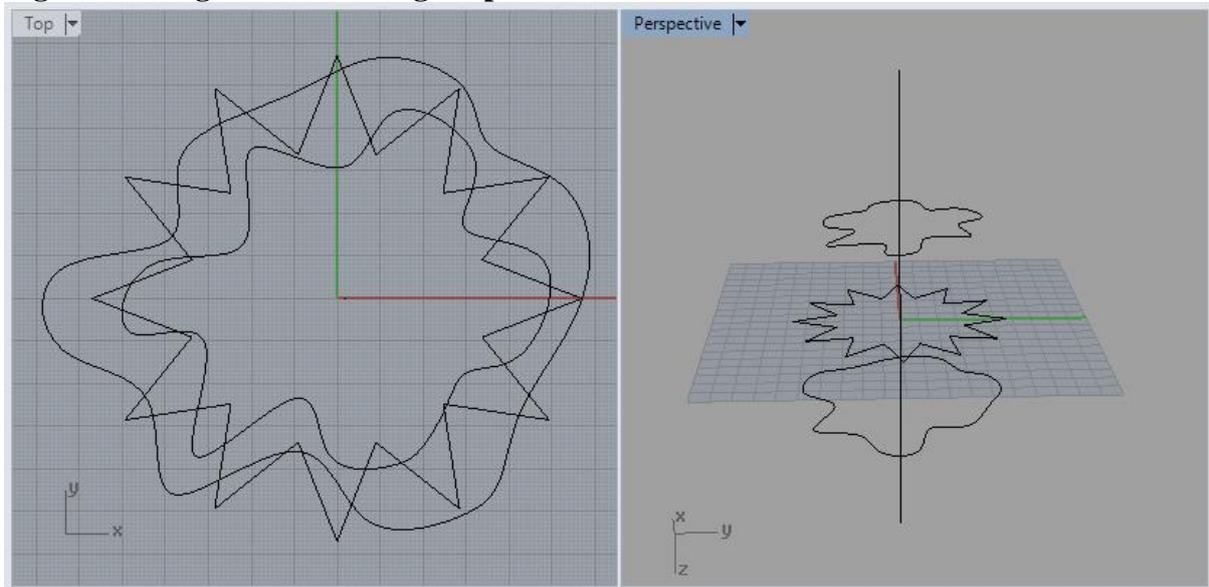


Source: Author's sketches

Abductively, the properties from 'a' and 'b' can be selected and in the software modeler they form a suggestion, a diagram-icon 'c' of what the sculpture could look like to meet the requirements of the artistic expression and the constraints of the technology and materiality (figure 2). The abductive guesses are informed by various concepts in the software modeler such as 'lofting' commands by which creating a surface from endpoints through the

diagram sections can result in a closed shape. This must then be compared with the initial idea in the feedback mechanism.

Figure 2 - Diagram icon taking shape in the software modeler.



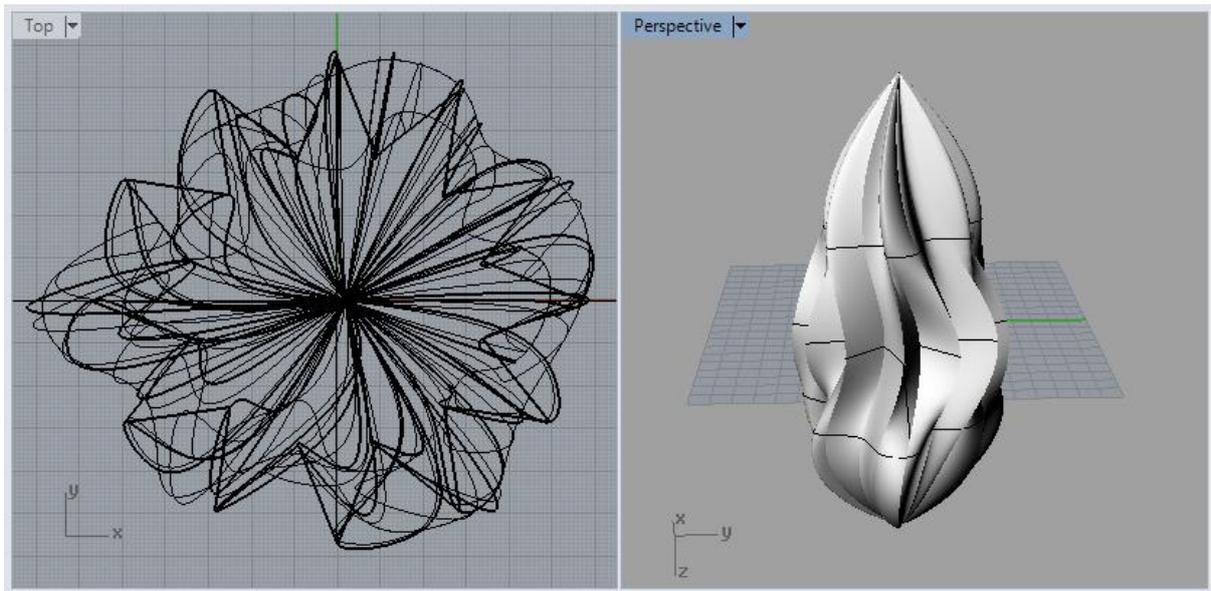
Source: Author's sketches

What matters is that the resulting diagram in the software modeler can be used as a foundation for experimenting in the transformation diagram.

3.1.2 Transformation diagram - experiments on the clean diagram

In the transformation diagram 'd', deductive experimentation can now be performed using the rule sets from the previous inductive steps e.g. the importance of the constraints of the material, the feasible printing dimensions, and the artistic intention. These can be traced partly from general assumptions about the sculpture deriving from lofting with the drawn lines in the software modeler and a relation between wall thickness and size of the sculpture according to its nature in this case as a 1:1 piece, and not a scalable representation. Secondly, they can be traced from the inherent need for logical consistency e.g. so the model will support itself, and not collapse, during the printing process. These are logical requirements independent of the nature of the result as an artwork or something of a different nature. Thirdly, experiments can be performed on the diagram according to rules regarding the artistic expression and intention of the diagram. The expression of the surface of the sculpture changes in relation to the size and shape of the curves and line used for creating the surface. The influence of the constrained syntax of the software modeler on the underlying geometry can be adapted through experimentation to meet an intended artistic expression (Figure 3).

Figure 3 - Experiments on the diagram by changing parameters according to inherent rule sets.



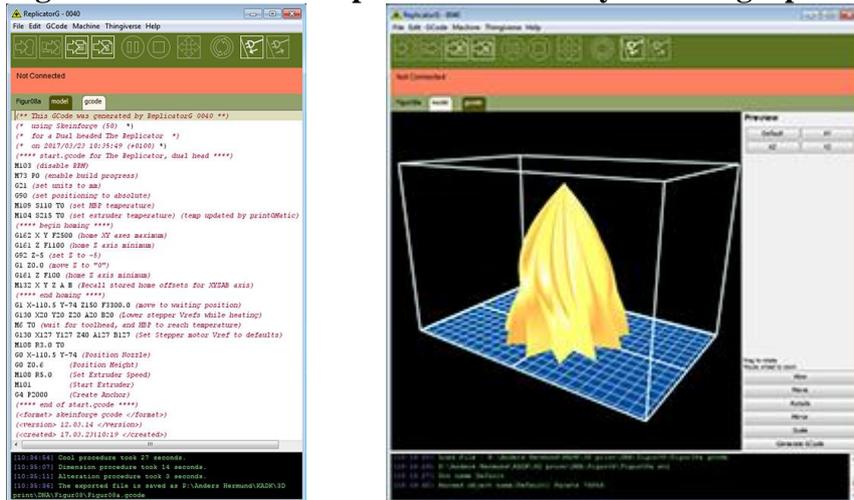
Sorce: Author's sketches

The question to why the diagram has been created is what motivates the whole process, and can in this case be derived from the premises of the artistic intention. At this stage, when the artistic premises are accepted and the diagram contemplated as if it was its object, and not just a representation, the 'imaginary moment' occurs. Now the experimentation is performed on the diagram's structural likeness to its object using the rules inherent in it. The diagram now operates as an iconic legisign. The artist is now performing his experiments as if on the final outcome of the artwork, through manipulating the relational parameters of the diagram. This means that contingency and conclusion exist simultaneously in the artwork during the imaginary moment. Thus the criteria for the experimentation will at this point also include an assessment of the diagram's possibility to sustain all qualities of the final artwork, such as materiality, transparency and colors. The experimentation results in the transformed diagram 'e' which can translated to a symbolic understanding.

3.1.3 From transformed diagram to symbol and post-diagrammatic interpretant

The Transformed diagram must be interpreted symbolically in order to proceed its objects' process of creation. From the software modeller a translation is required for the 3D printer in order to print the sculpture. The transformed diagram outputs sufficient information to permit an abductive selecting of the properties and settings for a translation into code strings (Figure 4).

Figure 4 - Gcode and 3D printer interface symbolizing a possible sculpture.



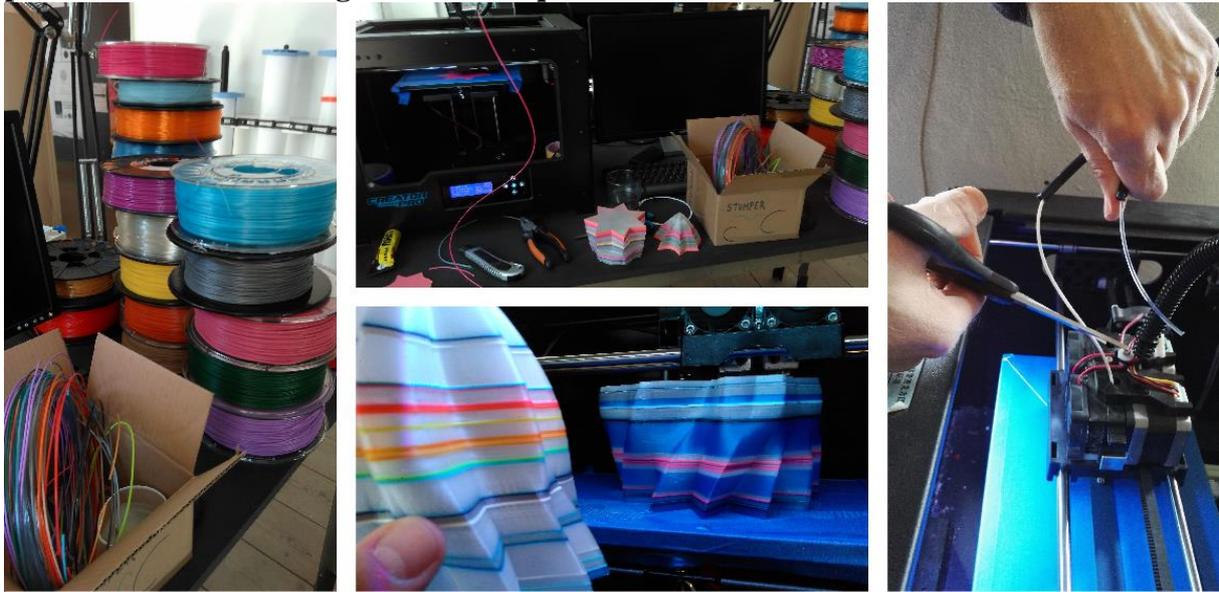
Source: Author's screenshots

The correct settings of heat temperature and speed are abductively suggested and the resulting new symbol 'f', in form of code strings, can in a post-diagrammatic interpretant 'g' be inductively compared with the intentions in the pre-diagrammatic interpretant 'b', and it can be checked if the diagram works and the intended artistic expression can actually be created. This assessment is both very rigid, i.e.: will it be technically possible to print, but also sensitive, i.e.: can the artwork sustain its intention artistically with the given expression? At this stage, the sequence of colors are not yet determined exactly, only the artistic intention of a desired outcome exists. Due to the nature of the specific case study, and the creation of the color sequence, another layer can be added to this diagrammatic reasoning. This leads back, through an iterated loop, to both the transformation diagram and the imaginary moment.

3.1.4 Iterated loop through transformation diagram

That the specific case study is a sculptural art work 3D printed in full scale allows for a certain second experimentation on its diagram. Using colors is a crucial part of the intentional artistic expression creating certain degrees of vibrancy in the shape and emphasizing a direction. Now the fully operational diagram can already be 3D printed, but crucial experimentation continues. While the 3D printer is mechanically producing the exact desired shapes by positioning melted plastic filament according to the diagrams' rules, the distinct colors are created by a manual artistic interruption. Without stopping the printing process, the given filament thread is manually cut and replaced with another color (figure 5).

Figure 5 - Colored printing filament is manually cut and replaced during the printing process in order to change the color sequence of the sculpture.



Source: Author's photos

This can be described as a loop back to the imaginary moment in the transformation diagram. At this exact time experimentation is literally performed on the diagram being the artwork itself and not a representation.

Figure 6 - Final sculpture samples from the case study



Source: sculptures and photos created by the author. [5]

4. Results And Discussions

The diagrammatic reasoning reflects artistic processes in several respects. To be able to carry out experiments on the diagram shows that a diagram can be understood as a framework for creation in this specific context.

Many of the above-outlined steps in the diagrammatic reasoning are more or less visible without a designated effort to analyze them. Especially when dealing with technology such as digital tools, the reasoning processes are happening very fast, and can seem to overlap, and even seem hidden. Discerning the differences between e.g. iconic and symbolic

signs, can seem inaccessible, without an understanding of the interrelation of the implicated signs. This is where the diagram has the potential to become a tool in more than one respect. This analysis shows that the semiotic diagram has the potential to assist a creative process, by creating an awareness of the correspondence between actions in the creative process. In this way all the steps in the process can be addressed, including the use of digital tools, and the language in which to communicate with the computer. In a creative process embracing digital systems, it is imperative to be able to address the role of user interfaces, which keep track of the binary codes for the user by providing choices and act as a translator between the user and code. By virtue of this, it may sometimes be difficult to figure out the basic principles of the way the software works. Controlling software in a desired direction, requires an increased awareness. This can be investigated in the stepwise analysis using the diagrammatic reasoning, and can contribute to increased awareness of a creative process.

5. Conclusions

The diagrammatic reasoning can be used as a framework to better understand the steps in the creative work with 3D printed sculptures, and it is shown how it is possible to use a Pierce inspired semiotic diagrammatic method to highlight the different types of inferences involved in artistic work. This analysis shows that it can be possible to organize the process of artistic creation according to a diagrammatic system that is flexible enough to contain an artistic sensitivity and unpredictability as a main driver and parameter alongside the technical requirements.

Using the diagrammatic approach can be useful as a framework for understanding the creation of art on a crossbreed platform involving both traditional skills, artistic inspiration, and newest technologies, such as 3D printing.

With the semiotic diagrammatic reasoning as a reference, we can pose informed questions about how an artistic process works. We can understand the creative artistic work as a series of interrelated signs, and discern the types of requirements for input in the various steps, and how these sign-relations manifest themselves and are perceived differently in different contexts. This paper's introduction to the diagrammatic reasoning can be seen as an opportunity to raise the awareness about the ongoing processes in the creative work of art in a digital context.

6. Acknowledgment

I wish to mention and thank the artist Morten Modin who has been of great inspiration through his works of art and experimentation with 3D printing in his artistic creative work.

7. References

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- [5] Part of the sculpture series were selected for the 2017 Greater Denton Arts Council exhibition: *Materials Hard & Soft*, Texas, USA (<https://dentonarts.com/materialshardandsoft/>).