Scientific Research Publishing

Creative Education, 2020, 11, 1843-1865
https://www.scirp.org/journal/ce
ISSN Online: 2151-4771
ISSN Print: 2151-4755

Textual Typologies Produced by Students by Transforming an Artistic Sign as Learning Indication

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How to cite this paper: Laburú, C. E., da Silva, O. H. M., Barros, M. A., & de Freitas Zômpero, A. (2020). Textual Typologies Produced by Students by Transforming an Artistic Sign as Learning Indication. *Creative Education, 11,* 1843-1865.
https://doi.org/10.4236/ce.2020.1110135

Received: March 26, 2020
Accepted: October 11, 2020
Published: October 14, 2020

Abstract

This study uses the transcoding process of visual perceptions of an image to written language in order to monitor the learning of physics concepts. Through this procedure, high school students were asked to write a piece of text that interprets an artistic work from possible connotative readings that associate it to the content taught. In addition to the scientific content domain by the learner, the discursive organization employed in the text is also examined. The discursive organization is based on descriptive, narrative and discursive typologies. In that sequence, they form an increasingly complex composing structure. The study starts from the assumption that the appropriation of the content taught tends to keep a correlation with the typological development used while constructing the text. Results indicate that dissertation organizations tend to indicate better understanding of the content when compared to narratives or descriptions. Thus, the study suggests considering text typology as a complementary tool to assess the learner's understanding of the taught content.

Keywords

Semiotics, Discursive Typology, Learning, Physics, Aesthetic Function, Transcodification

1. Introduction

Since the end of the 1970's, research in scientific education area has emphasized

*CNPq-Brasil Scholarship recipiente (process 301582/2019-0).

the importance of active participation of learners in the learning process. From the beginning, this was a reference for the interaction or action of the learner on the concepts and objects with the purpose of assimilate them; a view based on what has since been defined as individual interactionist constructivism of a Piagetian psychological foundation (Edward & Mercer, 1993: p. 18). From the 1980's and 1990's, the proposition that the acquisition of knowledge is made by the interaction between more and less competent members of a social community was emphasized. Known as social constructivism or social interactionism, such pedagogic guidance, of a Vygotskian psychological foundation, established language as the privileged intermediating constituting dimension of that interaction. This was due to the understanding that language and thought started to be understood as solidary cognitive mechanisms. Since then, the condition of an active being means the need of the learner participating in their construction of the scientific knowledge mediated by the sharing of the language. By that guidance, the learning of sciences is mainly supported by the socially developed symbolic instruments that need to be appropriated upon interaction between less expert and more expert individuals, and such interaction allows the student to access the meanings of the scientific culture.

Under the background of leading students to build denser and more permanent scientific meaning systems, and therefore, with broader sense, the concept of active participation of both educational approaches flourish when the interaction of the subject on the concepts, objects and among objects is gathered and, simultaneously, compete with language's representative and communicative roles. Through this double role and active participation, the learners can make their representation of the reality public by comparing, negotiating and changing them during the relationships they hold with each other. In this scenario, school teaching and learning actions are thereinafter guided towards valuing interactive and communicative procedures where learners are supported in a systematic and planned manner by their science teachers to develop knowledge related to given study fields of the reality. Thus, richer and more complex shared meaning construction mechanisms, suitable for those study fields, are stimulated.

Those works continued during the 2000's, with research extrapolating the psychological approach centered on oral language, even though other representative modes have already participated in a peripherical manner, but with no greater theoretical foundation. From them, there is a consolidation of the position that using multiple languages in classroom not only educates but also motivates, since, through them, the intellect is compelled to proceed transformations and reflexive amplifications. Supporting this position, semiotic foundations allow us to understand that the conceptualization of an object or phenomenon is intimately attached to its representation (Fidalgo, 1998). In other words, one cannot dissociate the formation and acquisition of concepts (*noesis*) from semiotics representations (*semiosis*) that exteriorize them (Duval, 2004: p. 14) and therefore, make them communicable; a position that is already present in the referred Vy-

gotskian psychological tradition (Laburú et al., 2012). Such position is essential for the scientific thought, since each activity and understanding of a scientific knowledge is built on their own symbolic domains, with singular properties, which are necessary and convenient to represent sectors of the reality, just as the relations maintained by their study purposes in the several fields of knowledge. Also, it is the nature of the scientific discourse to approach the same concept under several representation forms that must be interchanged and coordinated in an integrated manner during the communication process. It is from there that the scientific literacy of the students in the most varied areas of knowledge go through not only the domain of the most dominant verbal discursive manners, but also several other specific representations, ranging from algebra, chemistry, graphic, schematic, table, diagrammatic, geometric, tridimensional models in the form of scale models, and experimental types, among others. Such "literacy" becomes effective whenever a student shows not only the skills to operate with several equivalent representations, but when he is able to make conversions or exchanges and unions between them (Prain & Waldrip, 2006; Duval, 2004: p. 32).

Therefore, the first pedagogic concern that is presented is related to the establishing of several semiotic procedures within the classroom that lead the student to the understanding of the concepts taught. From what has been stated, that means seeking ways of maximizing the scientific multi-representation competence of the students in relation to the concepts. A likely action in that sense tends to locate the origins of the semiotic recalcitrances demonstrated by the student with the purpose of understanding their reasons when they are involved with the operation of several representations. Through this understanding, initiatives can be taken by the professor with the purpose of redirecting the teaching towards overcoming the identified problems. Studies in the area under a semiotic focus suggest some paths forward for those operations. Among others, it is worth mentioning situations where the students are requested to express themselves by their own non-formal representation productions regarding what they understand from the meanings of scientific representations. Another possibility is to encourage them to produce discourses where they need to integrate and coordinate several languages to express an idea and communicate a given concept learned or, for instance, when they are instigated to translate or convert different scientific representations where the condition is evidently the permanence of the learned conceptual equivalence. Furthermore, due to the unique nature of the teaching of sciences, one can also particularly request that based on the scientific representation studied the desired empirical effects be produced. In that case, understanding in its completeness implies in knowing how to do it. Indeed, one here pretends that the learner transfers any given representation (verbal, algebraic, etc.) into a concrete action, which is equivalent to transcribing or translating meanings of a representation of initial output to another terminal in 3-D representation mode (Prain & Waldrip, 2006: p. 1851; Laburú & Silva,

2011), which may even be externalized through gestures of the subjects (Laburú et al., 2015) when handling objects, equipment and experiments.

From the stated above, one can understand that the referential of the multiple representations in scientific education is in harmony with the fundamental principle of social-constructivist pedagogy that considers the discursive participation of the learner as a condition for the effectivity of the appropriation of knowledge and development of thought. Surely the confluence of discursive interactions with multi-representational articulation establishes a pair of solidary conditions for the systems of signification of scientific concepts to be built.

As known, the generation and conduction of interactive conversation within the classroom usually takes place through questionings, with an entire study regarding that topic (for instance, Kawalkar & Vijapurkar, 2013; Albergaria Almeida, 2012; Chin & Osborne, 2008). The use of formulating questions is usually the way professors take initiative to establish an interactive contact with their students (Lorencini Jr., 2000: p. 218). However, the questioning methodology is not simple to be applied, since very often the undesired setback of the attempts to dialog get shorter and prevent the maintenance of a more in-depth interlocution, quite often with professors little prepared for such challenge. The reason for such setback is due to the reduced number of students who attempt the dialog, and in general, their answers being very succinct and direct ("because it is", "because it is not", "I don't know" etc.). These kinds of answers, or absence of answers, are obstacles for the professor to complete a discursive interaction for long enough to develop argumentations and discussions and, with that, to guide the learning and improvement of the students' ideas. The professor who is convinced of the importance of this discursive dynamics, but little prepared to put them into practice, or who has difficulty in employing the formulation of questions, when frustrated in this attempt, quickly returns to the usual methodology of direct verbal transmission centered on one's own self.

In face of such difficulty, in Laburú, Nardi, & Zômpero (2014) a didactic path is suggested in order to face such issue. It employs the property that prevails in the artistic signs of the esthetic function in the semiotic transformation of transcodification (Joly, 2004: p. 72) to incite and sustain a discursive process in the classroom. Those authors showed that due to the aforementioned property, certain artistic signs can be used to instigate and support conversation processes with the students, if they have connotative potentiality with the scientific content. The reference to the connotative potentiality arises from the possibility of being able to establish conditions for the learners to be able to make readings that associate the constitutive topic of the artistic sign to the scientific content taught. With that, one seeks that learners' extract from own and unique singular esthetic narratives that the artist intended while sketching his work, narrative senses to be transposed to the scientific theme in play at the instructional moment. Therefore, by means of free creative and imaginative readings made by the learners, the professor establishes an oral discursive interaction with the students

with the purpose of guiding the learning. The work indicates that by using this teaching approach, a professor not very keen on interacting and holding a conversation with his students can reach greater ease to provoke and preserve a conversation process. The conclusion reached is that the interpretation of an artistic piece of work by the students, with appropriate configurations to produce connotations regarding the scientific content taught, allows the opening of a dialogic participation channel within the classroom, where the professor can use the work to generate and work on shared knowledge to the service of building the desired scientific meanings.

Advancing in the aforementioned work, the study proposed herein overcomes the issue of the dialogic sustainability and is concentrated in the examination of the scientific understanding of the learner when he sees himself submitted to a different trans-codification strategy. It starts from the discursive stimulation of students, purpose of the aforementioned study, but with interest focused on the learning diagnosed according to a unique procedure. With that scope, connotative interpretations of the written production of students regarding the artistic work *Waterfall*[1] by Maurits Cornelis Escher are analyzed. For such connotations, the students were instructed to trans-codify the visual representation of the work to a written representation, seeking to relate it to the physics topic studied. In order to qualify the learning, the authors propose the analysis of written productions according to the classical discursive typologies of description, narration and dissertation to use them as a complementary diagnostic to the subject learned. As observed, the work analyzes the writing structure developed by the student according to those typologies with the purpose of demonstrating the viability of making a diagnosis of the state of knowledge of what is being appropriated by the individual. On the other hand, it will in fact emphasize that the last discursive typology presents the compatible composition structure to reveal the actual understanding of the content.

Therefore, the study focuses on the organizational typology the learner provides for the construction of his textual production using a semiotic procedure of transcodification of visual language to written verbal language. Simultaneously, by identifying the discursive typology produced by the student, the study shows that this identification provides a supporting means to scrutinize learning, given that it starts from the existence of a link between typologies and appropriation of the subject taught.

2. Theoretical Foundation

Multiple representations and thought

Research in the teaching of sciences that exploit multi-modes and multiple representations addresses the impact of using several modes and representation forms in the classroom to encourage thought and the expansion of the conceptual meanings of the learners. As known, different types of sign representations,

[1]http://www.educ.fc.ul.pt/docentes/opombo/seminario/escher/quedaagua.html.

whether formal or informal, are intrinsically connected to differentiated mental faculties which can be stimulated (Santaella, 2005: p. 56), as well as favoring motivational aspects (Laburú et al., 2011). Several cognitive and motivational aptitudes of the mind are not developed or awoken based on a single mental resource, but from a variety of resources and representative schemes, each of them specializing to deal with a given form of communication, whose meaning is enriched by the use of several and different languages. Part of the functional power of the human brain originates from those different specialized forms of forwarding communication. They provide a unique repertoire of skills and talents to perform peculiar differentiations and combinations of units of knowledge, each of them contributing with their own characteristics to the enrichment of our understanding of the world (Santaella, 2005: p. 68). In summary, the signification process by sign action, known as semiosis, is related to the type of sign language employed, since it encourages a given way of thinking (Santaella, 2005: p. 43; Laburú et al., 2012).

Once thought is developed and improved within the several representation languages used, semiotic processes end up leading a more refined learning when provisioning teaching with combinations, integrations and transformations in differentiated representations (Prain & Waldrip, 2006; Duval, 2004). Especially in relation to the exercise of transforming visual perceptions to verbal language, or vice-versa, where the visual and verbal rhetoric issued must maintain an equivalent meaning, Joly (2004: p. 72) refers to this transformation exercise as transcodification. Although the transcodification from the visual language to the written verbalization is the object of our interest, and therefore, it will become clearer throughout the work, in order to clarify this concept, the authors present an example of an opposite case. Take, for instance, a professional in the advertising sector who has the task of producing a visual project to show a specific condition of a person or evoke a given concept, such as liberty, happiness or femininity, and must demonstrate in pictures the visual equivalent of a verbal project of such concept. In this case, it is expected that the professional is able to translate into images the same ideas the verbal concepts send. This task of transcodifying a verbal script to image, as noted by Joly (op. cit., p. 73), is not a simple one, and requires several choices.

The plural condition of the human intellect and its variety of thoughts, given the existence of several factors separated from cognition, as stated by Gardner (1995: p. 13, 42), are consistent with the transcodification actions. The latter, in as much as they imply different ways of thinking, activate and favor different cognitive potentialities of the individual, which strengthens the knowledge to be learned. From the plural and multifunctional perspective of the brain, it can be understood that individuals with diversified intellectual profiles, since bearers of performances and combinations that are relative and contrasting in the way of thinking, are at the same time benefited by having their thoughts provoked to seek the maximization of the meaning of scientific concepts through several re-

presentational routes of thought. By not acting like that, one fails to take advantage of aspects of the greater intellectual resourcefulness of each learning individual, and consequently, of the motivational appeal they eventually develop or activate. For similar reasons, there is an understanding that the gathering of learners in an argumentative cooperation, mixing different intellectual profiles, implies in mutual enrichment of the knowledge they are learning.

The foundations for the inserted positions are derived from the theories by Vygotsky (2003) and Peirce (Santaella, 2005). Both state that every thought is given through signs and that thought would not exist without them. In Peirce's theory, there is greater emphasis in associating sign not only to verbal or figurative language, but also equally to ideas, gestures, actions, reactions, feelings, scents etc. It states that the sign is capable of manifesting itself both externally in a semiotic representation (Duval, 2004) that requires material resource to provoke our feelings, but also upon interior thought that does not require such resource. Therefore, a sign is anything that presents itself to the mind or that is exteriorized, but regardless of its nature, it inevitably generates thought, meaning (Santaella, 2005: p. 55, 56). Therefore, peculiar characteristics of thought correspond to each given characteristic of the external sign representation form, reinforcing the positions in place.

Connotation, denotation, transcodification, esthetic and semantic function

The idea of transcodification of language can keep relation with the concepts of denotation and connotation. In order to demonstrate this, one must first mention that the comprehension of the two latter concepts goes through the understanding that every sign refers to a mutual arbitrary and conventional codified correlation between the elements of an expression (significant) and content (meaning) plans, establishing what Eco (2003: p. 39) refers to as a sign function. That said, semiosis can be considered as connotative when the significant of the sign is constituted by another sign whose meaning is correspondent in a second moment. Another sign is referred to here since the meaning is also other, that of the second moment. When giving the meaning at the first moment, semiosis is denotative. Here, the relationship codified between expression and content is that of the first moment, in the sense that a precise unit of content results in a precise connection with the unit of expression (Coelho Netto, 2003: p. 37). On the other hand, connotation sustains an indirect relationship between expression and content, more vague or ambiguous, since the referred relationship is capable of generating more than a single piece of content for the same expression and is linked to the reader's cultural aspects. Eco (2003: p. 46) states that the connotation exists at the expense of the denotation, and it is subsidiary to it, since it is nurtured by it and without it, it would not be instituted as a sign.

In other words, the code that comprises connotation is supported and broadcasted by the preceding code given by the denotation (Eco, 2003: p. 46). In going from a denotative to a connotative sign, the meaning of the former remains attached to the significant; however, it metamorphoses, going towards new mean-

ings, even if the significant remains the same. The ambiguity of the messages latent to the connotative act arises precisely from the permanence of the original meaning and the path the new significations may take. The overcoming of the denoted meaning and the delimitation of the connotative ambiguity results and remains dependent of a context (Coelho Netto, 2003: p. 25). In other words, the figurative meaning of the intended connotation is only discovered within a given social-cultural environment. It is from the simultaneous overcoming of the denoted meaning and coordination to a context that connotation is constituted. Therefore, connotation results from denotation plus cultural context where it is inserted. Barthes (1988: p. 187) helps to understand this with a simple example. At a first moment, someone wearing a fur coat denotes protection from cold, but within that meaning, it is possible to have a second meaning, which goes beyond that functional one, referring to an anthropologic and social value of wealth, power, economic status etc. It is the social environment where the sign of the coat is presented that builds its meaning. As a rule, it is a condition of the artistic language being creative and metaphorical, which makes it wealthy as a vehicle to transport connotations of extraordinary semantic loads, since its purpose is to suggest much more than what the object shows, triggering, according to the context, all sorts of ideas, feelings and emotions, as one can see in sale or ideological advertisements.

Regarding the concept of transcodification, that is, the transformation from one language to the other, as it takes place, there are inevitable gains and losses in the process. The reason for that, as reminded by Benveniste (1974, *apud* Duval, 2004: p. 66), arises from the fact that the signs do not work identically and do not originate from a single system, which prevents them from being redundant. Each representation system is not universally applicable, and their specific choice depends on the circumstances. Furthermore, all representations are cognitively biased in relation to what it represents and does not show an identical way of seeing and communicating the same message from the same content. That said, one can conclude that the operation of transcodification, especially when applied to artistic language, has the rule of overcoming, with greater emphasis, the esthetic function of the signs and their semantic function (Epstein, 2002), what is produced by means of connotation.

It must also be said that every sign is constituted of these two roles (Epstein, 2002). Therefore, there are signs where the semantic role is dominant, and in those cases, the logical character, the structure, the easy translation of a language to another prevails. It also allows active answers guided towards explicit purposes with precise determination of meaning, preparing it for action and observation, to experimentation and conduct. Signs with such characteristics, as the scientific ones, must be unique, accurate, and objective in order to ease communication, giving it credibility and authenticity to grant and ratify the proposed theories (Epstein, 2002: pp. 33-35). On the other hand, the esthetic role, dominant in artistic signs, can be distinguished by playing with violating the rule

(Eco, 2003: p. 224), with the limitless of senses, since its meaning can vary for different recipients or to the same recipient in different moments (Coelho Netto, 2003: p. 171). This role of signs does not demand single, exact answers, but prepares psychological states connected to sensations and feelings. That is why the esthetic message is able to present several meanings, and one cannot refer to a single, last and final sharing of content, but in polysemy. According to Coelho Netto (2003: pp. 169-170), esthetic information is fundamentally connotative, and the value of the esthetic state is usually as great as more "illogical" (emphasis added) as its form, and as farther from the current standards, becoming unpredictable.

Therefore, the transcodification process, in a greater or smaller scale, is accompanied by connotations whose messages, by force of the esthetic role, have semantic roles projected to the second moment. The efficiency of the connotated message transmitted is therefore dependent of a convenient and creative esthetic role, which must not only attract the feelings and the interest, but also must combine the conditions of discovery of the meaning intended by the developer of the transcodification. Another example presented by Barthes is a picture of a black young man wearing a French uniform, saluting the French flag, to help understand the above position. The purpose of the developer of the Picture was not to indicate the referred characteristics, but to connotate the following meaning, which can be verbally translated as: "France is a vast empire, where all its sons, with no prejudice of color, faithfully serve under its flag, and there are no better answers to the detractors of an alleged colonialism than the care of this black man in serving his alleged oppressors." (Barthes, 1988: p. 187). Therefore, the Picture, which can only be understood within the social context of the time, making the latter acquire a stratification of senses beyond those merely functional that the first composition of the artist intends to show.

Discursive Typologies

The sequential cohesion of verbal language is ensured by three great organizing principles of discursive sequences that are based on the descriptive, narrative and discursive roles. Through these three roles, one can set up variations and heterogeneity of every discursive ordination. Then each category is discriminated; however, its classical qualifications usually known are improved with the Peircean phenomenological definitions as coherently matched by Santaella (2005: p. 14). Consequently, the three typologies are amalgamated with Peirce's foundations, which allows one to better delimitate and refine each category as simultaneously expanding their analytical capacities, given the purposes of the work.

For Beaugrande & Dresher (1984: p. 239), descriptive texts are used to fill out knowledge areas where the control centers are objects and situations. Santaella (2005: p. 292) remembers that in ancient times, description was considered an insufficient definition; one would describe what one could not define. From the eighteenth to the nineteenth century, description was considered as an inferior way of learning, an imperfect definition. It was not related to the formulation of

an opinion though which one answers a question, nor by the indication of its foundation or conceptual manifestation of a development, but pure and simple fixed and immovable indication of something that appears by itself.

In the field of literature, it is considered as a mere companion of narrative texts, and most of the scholars have denied the status of autonomous gender to it, according to the author. Effectively, the description is reduced to a numeration, an inventory, a list of what is perceived, characterizing places, characters etc. Due to the unrelenting attendance of what seems to be understood, it is only denotated and goes through the retention of the characteristics of what is apparent or exposed to a first sight. Therefore, the description has the impression of a first glance, of denoted, of mere and simple immediate presence. It is a discursive type that seeks to elect in words the qualities of things. By describing, one translates into verbal language the apprehension we have of the attributes of things, if environmental, people, situations or even those that are produced by our imagination, since it is also constituted of an organ of the lower and spiritual senses (Santaella, 2005: p. 15). By the very nature of language that takes place in time through one word after the other, we are obliged to fragment the object into parts, detail by detail, following a temporal itinerary capable of recovering, step by step, the sensory apprehension of the instantaneous perception. In summary, since this apprehension is eminently through the senses, the description is characterized by the translation of sensorial apprehensions into verbal language of what initially does not need to be reflected, but only declared. Such translation is limited to the aspects of what is perceived, retaining the essential traits of its presence from the objects.

While it is a consensus among theorists to insert description as an organization of the language that is fixed on the registration of sensorial attributes of things, events, situations and steps, in turn, they consider narrative as the moment where action verbs start and are chained so as to generate some kind of conflict. In texts compliant with the narrative style, language is structured in a succession of events in a time or contiguity sequence. It is characterized by actions and events in time, in a linear or non-linear sequence. In this latter case, it is not important in which point a story starts to be told, the temporality thread will always be present and in any way rescued in the narrative. To the static status of description, there is the dynamism of narratives. However, it must be said that in a given sense, both the description and the narrative assume temporality, even if in different ways. While for the first one it is continuous, the changes related to the second one cut the time in discontinuous units (Todorov, 1980: p. 62). In description, since there is no own and inherent Direction to objects, there is no reason for the exposure to start at any arbitrary point. For instance, a person can start to be described by their eyes or by their shoes. However, one must note that the simple facts taking place do not constitute a narrative. For Bremond (1971), every narrative discourse must integrate a succession of events or experiences of human interest in a unit of the same action, so that the facts are

organized into common elements. Where there is no succession and integration into one unit of action, there is no narrative, only chronological overlapping, enunciating a succession of non-coordinated or correlated events.

For Santaella (2005: p. 322), a narrative is guided by the universe of doing, by the action being narrated, disregarding any causality or law, but, on the other hand, it reveals temporal and dramatic aspects. It is a verbal discourse differentiated by the linguistic registration of successive events or situations that are interconnected and integrated, generating a story, whether it is factual, situational, fictional or any other. In the author's understanding, the frontier between description and narration cannot just lie in the static character of the former in face of the dynamic character of the latter, as proposed by a few, since it is not easy to explain what can be understood by those terms, since it is a problem to say that dynamic involves time and static does not involve time when related to verbal language. Even in description, by imposition of the temporal nature of the unravelling of the word, the passing of time is necessary to detail and recover the instant. For that reason, she considers that the narrative starts at the moment action verbs are linked to start elements related to the idea of conflict, coercion, confrontation of forces, fight of any type, determination, correlation, end, need, occurrence, fact, surprise, doubt, result, polarity, here and now, among others, that are arranged in an interlinked mode in a sequence in time. For Greimas (*apud* Volli, 2012: p. 116), in the center of the narrative, in addition to an action to be made, there is a task that must be developed, a material object or ideal to be conquered, reached, pushed away, or avoided; in other words, a value to be taken. There must be something that must be accomplished, a mission, or a problem to be solved. Since it is constituted of character actions, the character himself could not be defined without the specification of such actions. It must be said, on the other hand, that action verbs by themselves do not refer to a narrative, that is, "pick a knife up" and "hold a knife" are both action verbs, but according to Santaella (2005), the difference between the descriptive nature of the first statement against the second one lies in that the latter insinuates a seed of drama that places it closer to narration when compared to the former, embedding an active attitude in face of the world against the more contemplative attitude of the former. In essence, the narrative increases the timely and dramatic aspect, with beginning, middle and end connected by a causal link, while the description longs on objects and beings in their simultaneity, facing the processes as spectacles (Genette, 1971 *apud* Santaella, 2005: p. 324) and the linear thread of timeliness obliged by the verbal presentation is completely arbitrary.

In relation to the dissertation text, it shares with the descriptive text a deeply timeless structure, which lacks the specific chronological characteristic of a narrative text (Chatman, 1978). The dissertation textualization deals with logically structured conceptual networks. There is the formation of hierarchies, generalities, regularities and systematicities appreciated through laws, rules and causal factors, thus, of the feeling of need. The concept of argumentation and

rhetoric is the one closest connected to the dissertation. Aristotle defined the concept of argumentation as the art of the intellect of extracting from each matter the level of persuasion it holds, of proof, or reasoning, of syllogism. While the properties of the objects are made visible or imaginable in a description, in argumentation the destiny is the proof, the same way as the validation of propositions, of considering the casualty or law, of governing facts in the future, of the how and why of events, ultimately, any general sorting, classifying and regulating principle governing the occurrence of an event. The dissertation is organized to develop concepts, formulate opinions and answer questions with principle. For Santaella (2005), every discourse with such configuration is born from a reasoning that, consequently, is constituted in an argument, once it implies the passing of assumptions to conclusions guided by inferential rules. Such rules, qualified as abductive, inductive and deductive, divide the arguments and comprise the crib and root of the dissertation. Once the dissertation is fundamentally structured on mental operations that are translated into laws and concepts, conceptualization produced by rational conviction of a general character can be considered as its most legitimate ingredient. In the case of the concept, its simplest example can be found in definition. Defining is organizing things according to general laws, that is, organizing them into categories (Santaella, 2005). Thus, dissertation is the language of generic and conventional formulations.

In a nutshell, while in descriptive language one is before the verbal register of the impressions of quality the things arise in our senses, in narratives, one is faced with the record of concrete acts, singular experiences, whether they are existential or fictional, and finally, in dissertation, one faces a reality that has a purely intellective, rational way of expressing itself, and as such, it has a universal nature, requiring familiarity and mental habits of inference. Therefore, there is a description without narration, and narration without dissertation, but not the opposite. Therefore, a description is not enough to create a narrative, as a narrative is not capable of creating a dissertation. Nevertheless, part of the descriptive texts is inserted in the narrative and part of these texts are inserted in the dissertation. By comparison, a verbal exposition is capable of having a rudimentary form of a description or a more elaborate form of a dissertation, or yet, finding its more optimized form in dissertation (Santaella, 2005: p. 287). From this gradual constructive qualitative property, it is possible to establish levels of sophistication and discursive improvement.

Discursive typologies and learning applied to the Waterfall image

The inclusive continuity of the discursive categories that ranges from description to dissertation, going through narratives, holds more and more demanding intellectual elaborations both in form as in content. The overlapping of both aspects is explicit, since the sophisticated rhetorical structure of a dissertation essentially needs to have acquired knowledges, different from a description, that only needs and is supported by the first impression of the look of a simple and immediate finding.

Taking that into consideration, it can be said that the written verbalization of a visual message manifests itself by perceptive and recognition choices that rule its interpretation, once all interpretation of an observation is made in the light of a theory (Popper, 1993: p. 61). In as much as theory here is related to the content taught, the interpretation of interest is related to the one the student must establish between the scientific concepts studied and the *Waterfall* picture (see note 1). Given the interpretative precariousness of the description, that denotes what is exposed at first sight, and the insufficiency of the narrative, since its interpretation is based on the actions observed without taking the "hows" (laws) and "whys" (causes) into consideration, the dissertation is the only discourse that presents a more complete intellectual organization capable of interpreting (connotating) Escher's picture through articulation with scientific laws and concepts.

With the previous assumptions in place and within their context, it is possible, at a first approach, to correlate discursive typologies and learning. The correlation is consolidated once one considers complex reasoning, dissertation textual form and acquired scientific knowledge as simultaneously overlapping. Thus, evidencing non-superficial and non-mechanical understanding of the scientific knowledge taught implies in using them against argumentative thoughts in reading the work of art, that, in turn, involve intrinsic and weighed mental operations, whose full performance can only be satisfied via a dissertation. Only such textual organization allows to identify the effective cognitive elaboration of the learned content. This is because the other organizations provide non-satisfied, partial or insufficient indications of learning. In the case of description, due to its trivially denotative nature of the reading of the picture, such fact becomes quite evident. Furthermore, as a corollary of what has been stated, one can state that more intrinsic reasoning is held always depending of greater knowledge, preserving the correspondence between more developed thoughts and more improved language (of the acquired content) (Vygotsky, 2003).

Therefore, this study is guided by the assumption that it is possible to establish a relationship between levels of sophistication of the textual composition of learners and their appropriation of content, thus authorizing an association between learning and the discursive typologies used. Therefore, it considers the existence of a strong bond between the understanding of the content acquired by the learner and the argumentative development with which the free structure of a text of an artistic topic which, at first sight, is not related to the studied topic, but when given the task of transcodifying from visual to written, connections between the scientific content and the image can be found. In principle, it can be understood that dissertations from the learning subjects imply in greater appropriation than in narratives or description forms. However, care must be taken with the generalized use of that guidance, since its scope belongs to the necessary but not sufficient condition. In other words, according to terminology from Prieto (1973: p. 52), there may be a "misunderstanding" in a communicative

dissertation structure instead of a "good understanding"[2], even if "not understanding" must certainly imply in rudimentary descriptive and narrative typological organizations. Now, in these two latter cases, learnings that do not take place or that are precarious or insufficient are limited to producing readings that remain stuck to the actual meanings the work sends out, without the learner being able to leave them behind and find relationship with the scientific concepts.

It is important to clarify that the term "good understanding", even if self-clarifying, since it means, within the context of this study, obedience or compliance with the scientific canons taught by the professor, it is important to differentiate and better specify "misunderstanding" and "not understanding", since they are analytical instruments used in this study. In parallel with Prieto (1973: p. 52), the term "misunderstanding" takes place when there is a mismatch between the message sent out by the issuer (professor) and the one attributed by the recipient (learner); even if the latter does attribute a message to what has been communicated, with the understanding of something, which is different from the one the professor issuer aimed at. If the learner is unable to determine the professor's message, the term "not understanding" is used whenever the ambiguity of the transmitted message does not disappear and there is still uncertainty. While in "misunderstanding" the uncertainty of the learner completely disappears, in "not understanding", his previous knowledge continues unaltered and there is no understanding of the new knowledge.

Once these clarifications are made, and based on the explanations above, the analytical criterion is established to assess the quality of the learning into "good, misunderstanding or no understanding" of the discursive typological configurations, where the attributes of the two initial ones are accommodated by dissertation texts, while the latter quality is accommodated to descriptive and narrative texts produced by the students as soon as they are requested to make readings of an artistic sign chosen by the professor and which has the potential to be correlated with the instruction topic.

In summary, the problem that is presented to the study is the feasibility of the aforementioned association. In order to do this, the students must transcodify into textual language an artistic image that can be connected to the content taught. As soon as this possibility is stated, an additional, auxiliary and complementary procedure starts in order to diagnose the performance of learning during instruction moments.

3. Methodology

Choice of artwork

The painting *Waterfall* by Maurits Cornelis Escher (note 1) was chosen due to the following points: its topic is compatible with the physics concepts involved with mechanic energy and the law of conservation studied; the work has an expressive power in that it presents an iconic nature that allows to excite concep-

[2]Prieto (ibid.) only employs the term "understanding".

tual impressions compatible with the concepts studied in the mind of the students; there is a situation of violation of the law of conservation of energy, but only noticeable in light of the aforementioned concepts and laws; the work presents a connotative potential, which means that it invites indirect associations, which are not obvious or automatic, thus not denoting the referred concepts in an explicit manner. Therefore, upon a careful reading substantiated by the physic concepts taught it is possible and feasible to look at those associations, obliterating or overcoming attractive esthetic compositional aspects of the image irrelevant to the physic concepts addressed.

Therefore, it is expected from the students, due to the teaching, that they are able to draft a dissertation depicting the Picture as a case of violation of the law of energy conservation. In order to do this, one must explain that the consumption of energy to make the mil turn, generating rotation kinetic energy, derives or originates from the consumption of the potential gravitational energy of water. However, the reused water has its potential energy increased and reestablished without the existence of an external source to elevate the water mass to the original level, in violation of the physics law of energy conservation. With that, the learners who dominate the law should notice that the water current acquires potential energy from nothing, since it returns to a greater initial energy level without a physical process of performing any external work, caused by the optical illusion built by the artist. The work is related to a perpetual motion that infringes the law of conservation of mechanical energy. In contrast with the most widely known perpetual motion machines, the one depicted by the artist encourages an esthetic judgment, thus, its perception is generator of feelings and emotions of beauty or disgust, with potential for more thought-provoking understanding and interpretation for the learners on what such imaginary machines, with their captious tricks difficult to be unveiled in the schemes of their proposals, requiring a domain of additional physic concepts if they were to be used with similar didactic purposes.

Sample, teaching context and data collection

The data obtained in the research originated from a sample of 36 secondary education students attending the second year in a public school with predominantly urban middle-class profile. The subject of mechanic energy was taught during five 50-minute classes. From the second last class until the middle of the last class the professor resolved energy conservation exercises with the students, discussed perpetual motion machines and concluded with a problem based on the methodology of open problems (Gil et al., 1988). The latter had a styled image of the roller-coaster looping problem usually found in textbooks, which was designed for the class to discuss collectively within the dialogic and authority proposal (Scott, 2006), and methodology by questioning (Albergaria Almeida, 2012; Chin, 2008; Hargie, 1983). At the second half of the last class, the Waterfall painting was equally presented to the class and a sheet of paper handed out to each student. The paper had a heading which was read and commented by the

professor, which requested that the student drafted a text regarding the meaning of the picture and its relationship with the topic studied, as follows: Draft an essay regarding the meaning of Escher's Waterfall and try to relate it to the topics studied in class.

In order to prevent doubts in the transcodification task requested, and for the "misunderstanding" or "not understanding" qualifications not to be present due to any doubt, during the fourth class, the professor also practiced with the student a task similar to the one related to the waterfall picture, but using a cartoon with the specific concept of kinetic energy. With that, it was sought to clarify any doubts regarding the procedure. At the moment of writing the reading of the picture, the task with the cartoon was recalled.

The essays were collected, and the texts analyzed according to the typological categories and association with learning in obeying the following criteria. If there were only simple descriptive references, thus the inexistence of connotation, or an existence of an attempt to interpret the Picture by the introduction of Physics elements or not, but that have not steered from a narrative determined by temporal, action or dramatic aspects, with the absence of any identification and justification of causality and law involved, it was established that it was the case of "not understanding". If the essay presented an advanced dissertation typology, but with a misleading understanding of the physics concepts, or otherwise, if those concepts were considered and applied in coordination and coherence in the reading of the picture, explaining that it depicts a real impossibility, since it violates a physics law, it was established that it showed "misunderstanding" and "good understanding", respectively. Similarly, since the textual typologies are not tight categories, with precise delimitations that separate their notions, the appreciation of the students' textual production considered the predominant typological standard and the most relevant in the text, since except for descriptive typology, the other categories carry elements of its predecessors, as previously explained.

The four pieces of writing presented in the following section are related to different students and were selected as they best typify each discursive typology and understanding condition. Only some excerpts are presented herein due to space limitations, suppression or redundancies or by not adding greater elucidation to what is already evidenced. In coherence with the previous paragraph, the excerpts also sought to picture the typological degree that predominated in the text together with the important learning aspects. Finally, the authors opted for rewriting them in specific passages to adapt to the educated language, preserving the original meaning of what had been written.

With the purpose of clarifying and better understanding the essays, missing words that should have been expressed by the student are presented within brackets, in addition to complementary notes and explanations made by the researcher. Regarding the reliability of the analyses, the works were submitted to a peer triangulation process (Paiva Júnior, 2011). In order to do so, three analysts,

with physics background, examined the texts using the definitions of the theoretical part and the aforementioned criteria as bases, and in a joint decision, sought to reduce inconsistences and contradictions in the individual analyses so as to compose convergences of interpretations.

4. Data Presentation and Analysis

The students' essays, as observed above, are presented and analyzed first according to the typological criterion of the discourse used and, then, the type of understanding of the content taught is characterized.

Student 1

ESSAY: *The house is built* (and) *surrounded by a wall full of steps, terraces, and plants. The water falls from the top with energy and turns a large water wheel. In front of it, there are four plants that I have never seen; there are some* (plants) *that seem like sea coral, and I think none of them exists;* (the plants) *are from a pre-historical period. They look like clay vases to store cereal in ancient Egypt. The stairs near the person who is looking over the eves is very strange because halfway* (in the middle) *it seems to become very steep and one cannot climb it, what is it used for, I wonder? It is a strange house, it is very high, where a woman hanging clothes out to dry and on top of the pillars there are two objects that seem like the crystals we saw during the chemistry class.*

ANALYSIS: Even though there are narrative elements due to the presence of action, doubt and amusement verbs (underscored lines), they do not seem to be linked in a temporal sequence that leads a character to a purpose beyond the one demanded by verbalization. On the contrary, a descriptive typology is preponderant throughout the essay, since the student takes time on objects and beings, restricting himself on what can be arrested by visual sensitivity. The student is concerned in presenting details of the work, retaining in making specific aspects of the properties of objects visible or imaginable, and discards any essential relation with physics concepts; in fact, it can be noted that the only concept emphasized is the word energy of the water to turn the wheel without greater consequences. Stuck to the very nature of language that happens in time, of one word after another, the student fragments the object in parts, one detail after another. After that, a temporal itinerary capable of recovering the instantaneous sensorial perception, step by step. Given the apprehension being eminently led through this perception, the description is characterized by the immediate translation of the observed into a verbal language of what, at first, does not need to be reflected, but only declared. Such translation is limited to the aspects of what is noted, retaining the essential and overlapping traces of its presence. Given the presented herein, the sign is treated in an exclusively denotative manner, with no connotation with the topic of the classes, and therefore, the task is classified as "not understanding" the content taught for this student.

Student 2

ESSAY: *It is a project built by* (means of) *a complex of walls in a kind of villa*

or something similar to that for the displacement of water, *which moves water upward for some time and then it falls back into the waterfall that moves* (the water current) *through accumulation pressure in time. The waterfall exists because the water falls due to gravity*, *attracting it down*, *the water*, *in turn*, *moves the wheel*, *and the wheel puts the water back in the path of the waterfall. It is a cyclic system*.

ANALYSIS: The essay goes beyond the mere description of the work and presents the prevalence of a textuality based on a narrative. This can be observed by the temporal and coordinated chain of descriptions, despite the existence of causality elements (... because the water falls, due to…). The prevalence is noted because the essay is based on the organization of action verbs that do not only join ideas, but fully relate them to determine an event, a purpose or a need (*A project built... for the displacement of water… moves water upward…falls back… attracting it down…moves... puts back*). The essay shows the insertion of three physics concepts (underscored lines) in isolation and without composing an articulation with the content of energy conservation taught. In the text, there is a confluence of a narrative focused on the moment inherent to the theme of the work, with the insertion of sparse elements of scientific language appropriated from the instruction, but which do not assist a connotative interpretation of the picture from a point of view of the physics concept of energy and of the violation of its conservation. Therefore, the quality of understanding is shown as "not understanding".

Student 3

ESSAY: (There is) *An architecture that was designed to use the gravity force to displace water in a cycle without using any mechanical force*, *only gravitational force*, *for it to reach its final position in the highest place and be used to turn the wheel. This movement is called motor energy* (kinetic), *it is an ancient system used to make some work such as crushing corn to produce flour and* (therefore) *not using animals turning in circles to work not exploiting and protecting them. The water needs a motor energy* (kinetic) *in order to be able to reach to the top of the structure and go down as a waterfall. The water is in the opposite direction*, *it seems it is going up against gravity. The motor energy* (kinetic) *of the wheel comes from the potential energy of the water it gained when it went up the gutter and is mgh* (potential energy formula). *The water comes from underneath and goes up; it is similar to a water fountain that recycles water. It preserves the same water. The energy of the water at the highest* (point) *is* $E_p = mgh$ *and it falls for the machine* (water wheel) *to operate*, *and everything is conserved. The energy of the work is equal the energy* (potential energy) *of the water*, $E_p = \tau$.

ANALYSIS: In a general way, the essay is organized as a dissertation. However, the first sentence is a narrative registering the displacement of the water current to reach a higher level with the purpose of moving the water wheel only intermediated by the action of the gravitational force. The second sentence is

coordinated with the first one to explain the work developed by the wheel. The third sentence presents an element of need ("... the water needs energy…") used to justify the energy ("motor") of the water to reach higher levels. From there on, the reasoning is completed with the argumentation that, since the energy is preserved, the work performed by the wheel is caused by the potential energy acquired by the water. There is a prevalence of the formulation of reasonings with the interconnection of concepts in the form of laws. The reading of the artwork extrapolates the observable in that the student takes into consideration several physics elements taught, such as gravitational force, cycle, potential and kinetic energy, which are not present in the picture, but are connotated in light of the knowledges taught. The terminological impropriety related to the kinetic energy being named as motor energy does not cause any further problem in meaning. A partial understanding that the energy is preserved can be noted when it is stated that work is equal the potential energy. However, the learner does not characterize the situation presented as a violation of the conservation of energy, despite seeming bothered by the water going up against gravity with no mechanical means ("…*seems to go up*…"). Such issue, not originated from the reference of physical foundations taught, is originated from common sense, and that is sufficient for the conclusion. Even if the student expresses isolated algebra formulas and applies the concept of equality and conversion between potential, kinetic energy and work in a restricted mode, it is clear from his appreciation that he is not uncomfortable with the energy in the form of work produced by the wheel originating from potential energy, and that it is continuously generated by the rising of the water without any consumption of energy for that. Due to those local and partially coordinated examinations, since there is a disregard of an analysis of the system as a whole, there is evidence that the student does not notice that the conservation of energy is transgressed. Therefore, this is considered as a "misunderstanding" situation, since the concepts learned were not appropriately applied to the task at hand.

Student 4

ESSAY: *The painting shows water circulating without stopping, it comes from a higher place and turns a wheel, then it goes back up on the ramp* (aqueduct), *which is impossible without an engine to pump* (the water) *because it goes against gravity. It is similar to continuous movement* (perpetual movement) *machines the professor taught us. When gravity exerts force over the water during the descend, it puts it into movement, and it gains kinetic energy* $E_c = mV^2/2$, *it forms a waterfall and that energy comes from potential energy, which is mgh. One can use the energy of the movement of the wheel, similar to a hydroelectric power plant, to perform the work, which is* $F.d.\cos\theta$. *Then, the potential energy in it* (water) *has a greater value when it falls on the wheel and loses some by friction in the air and* (friction on the shaft) *in the wheel* (,) *and the wheel performs the work with that energy.* (Then, the water current) *exits the wheel with less* (kinetic) *energy than it had at the top* (potential energy). *This cannot happen*

due to the energy conservation law. It can be seen in the picture that it (the water) *gains kinetic energy while going down, but it does not lose it while going up. If the water spent its energy to move the wheel, it cannot go up to the same energy* (potential). *It is energy all the same, but it does not keep the energy because work is being made and energy is being lost by friction. It has to keep it* (the mechanical energy), *work cannot be made always with the same energy of the water; the water cannot gain the same initial* (potential) *energy* (,) *it does not go up the ramp* (aqueduct) *alone. It is a trick* (from the artist), *it cannot happen in real life.*

ANALYSIS: Except for the initial descriptive section of the first sentence, everything else is connotated in a dissertation manner. This is because its statements, at the same time they exceed the observable, they are constituted of reasoned and justified sentences, with the expression of ideas that follow arguments based in laws and generalizations to prove them. The underscores show examples of terms that aim at persuading the propositions, with imperative positive or negative sentences, with conditional causality function (if...then) or need. The full rhetoric is structured on a network of interconnected concepts whose destination certifies, by inference, the idea regarding the event viewed. Regarding content, it can be noticed by the reading of the picture the appropriate and consistent use of mechanical energy concepts, and also, specifically of the corresponding law of conservation of energy. The student appropriately associates the illustrated event with the topic of perpetual movement machines studied. Based on the referred law and the physics concepts involved, the event is correctly perceived as a denial of an impractical event in real life. Therefore, the student shows "good understanding".

5. Discussion and Conclusion

The analyzed cases corroborate with the provocation guiding the work that a teaching task based on a transcodification process of an artistic sign with the potential of application in the content taught, when stimulating the free and creative connotation between them, tends to establish a correspondence between the organizational complexity of the discursive composition developed by the student and his performance in the appropriation of the knowledge taught. In that manner, a simple or inadequate discursive organizational typology built, stuck to the denotation of the observed, and indicates the inexistence or insufficient appropriation of knowledge. Consequently, descriptive and narrative compositions are usually associated to "not understanding", as shown above by students 1 and 2, respectively. On the other hand, the condition of "good understanding" is usually presented in dissertations, as shown by student 4. However, "misunderstanding" of the content is not fully discarded in that typology, as expressed by student 3.

Similarly, the semiotic action of denotating and connotating the image through the dimensions of transcodification, typology and appropriation of knowledge

can be observed. This is because the representational exchange related to the former can only be accomplished based in denotation or connotation. Regarding the two remaining dimensions, at the limit there is a denotative Reading stuck to the descriptive composition and of "not understanding", or, in the other typological extreme, a connotative reading tending to dissertation with the need to relate contents taught, even if they may be qualified as incorrect learning ("misunderstanding") or effective learning ("good understanding").

The four specific cases presented in this study are characteristics of a general pattern that is repeated. It is actually possible to imagine and investigate that such analytical pattern is extended to several situations of content, which implies in discovering or inventing new images, of students in similar or higher age groups, since the associations promoted are based on the general principle through which the construction of deep meanings usually arises from more developed discursive typologies, and vice-versa. However, it is important to mention that the analytical proposal has its own limitations. In fact, there were some essays that could not be clearly classified within the typologies due to the writing being considered precarious, ambiguous, clumsy, or excessively reduced for something to be stated with a minimum degree of reliability. Such exceptions had no interest for this work, since they did not allow for the interconnection of typology and the understanding of the subject taught. However, they could still be classified as "not understanding", as they actually were, since obtuse texts usually reflect that state of understanding.

In general, the certification of the state of understanding can only be ensured if other forms of analyses are added, which is extended to the examples presented, given the principle of prudence in examining performance or not of learning through the triangulation of different diagnoses. Thus, in face of the reasons expressed above, the proposal does not intend to be self-sufficient as a criterion for understanding the content built by the student. It only intends to be a complementary and subsidiary option for diagnosing the state of understanding of the student in a learning process, since it has the purpose of being an alternative teaching task, considered to be thought-provoking by the students, after their effective participation.

In general, the transcodification task made feasible by the work of art due to its inherent esthetic function, allowed to restate that the thoughts of the learners may gain expressiveness and inventiveness, allowing freer and more open minds to correlate the content taught to the topic of the work of art. The specific didactic guideline proposed by the study was successful, since it is able to reveal the understanding of the learners, since they did not need to be imprisoned by strict school guidelines of resolving exercises that usually dominate the classroom. Such guidelines are likely to show only mechanical learning, restricted to algorithms and automations that do not act towards deeper thinking, such as sought by the proposed methodology.

A specific aspect of the study points to students who presented a descriptive, narrative typology or whose essays were insufficient to be classified. In those

cases, one could wonder that maybe the problem is not in the not understanding of the didactic strategy. Therefore, this is another point for further investigation: whether those results are dependent of the difficulties found by the students in understanding the task, despite the efforts and clarifications in that sense.

Nevertheless, regardless of the importance of locating the causes of difficulties of the students presenting descriptive, narrative typologies or those impossible to be classified, the greater purpose of the professor is in seeking the overcoming of such difficulties and assisting the learners towards building dissertation discourses with scientific appropriation and, mainly assessing that accomplishment through new creative expressive representational forms, which could go through transcodification to written or oral language.

Finally, the greatest contribution of the study is the message that looking at the discursive structure of the student is a resource that can assist the professor in scanning how learning takes place.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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