Communication, digital media and future: new scenarios and future changes

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edited by
Elisabetta Gola, Andrea Volterrani, Fabrizio Meloni

RESOCONTI /1

This volume collects a set of meaningful full papers of Medcom2020+1 international conference, which has been organized by the University of Cagliari, University Hospital of Cagliari, and University of Tor Vergata (Rome). The conference has been held online from the 17th to 19th June 2021, on "Communication, digital media and future: new scenarios and future changes", which is also the title of this volume. The general topic has been divided in 8 sessions which range from social media to screen culture, from media education to social communication, politics and multiculturalism. The general topic has been divided in 8 sessions which range from social media to screen culture, from media education to social communication, politics and multiculturalism The topics also embrace reflections on the experiences after-pandemic, that had a strong impact and caused many changes on communication and society. The proceedings of the conference include a selection of 22 papers out of the about one hundred talks from the conference.

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Knowing through Metaphors: Metaphorical Devices from Science Communication to Science Education

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Abstract
Preparing students for life in an increasingly technical, complex, and global dimension is a relevant aspect of the current educational reform. To this end, international education researchers and practitioners are focusing on improving the persistence and success of students in scientific disciplines. The connections between Science Education and Science Communication, intended as a cultural activity that produces meaning about science, are receiving growing attention and have relevant educational potentialities. Scientific evidence shows that using metaphorical devices can improve learning processes involving scientific concepts (Amin, 2020; Fuchs *et al.* 2018). This contribution presents and discusses the research project "Knowing through metaphors". The project's central research hypothesis is that metaphorical-narrative teaching methodology, compared to traditional Science Education methodologies, is characterized by: a deeper understanding of scientific contents; the development of the ability to recognize implications and to activate new connections and easier access to scientific concepts for students with special educational needs. Such hypotheses were tested by developing experimental lesson plans that systematically use metaphors. The teaching models were implemented in six classes: two classes of the fourth grade (Primary School), two classes of the fifth grade (Primary School); two classes of the first grade (Middle School). For each grade, two parallel classes took part in the project. One acted as an experimental group, and the other as a control group. The emerging results suggest that the narrative-metaphorical methodology supports the long-term acquisition of the scientific contents and is more effective in activating new connections and supporting interaction. Finally, the presentation addresses the critical aspects that emerged from the research project.
Keywords: Metaphors, Communication, Science Education, conceptual innovation.

Introduction

Within the fields of Science Education and Communication, the role played by narrative and metaphors in fostering meaningful learning processes and conceptualizing new ideas is the subject of a growing number of studies[1]. Such innovative perspectives refer to the theoretical bases developed within the so-called new wave in narrative and metaphor theory, that focus respectively on the complex cognitive operations implicated in creating and comprehending stories and on the inferential and conceptual processes involved in metaphor use and understanding. The necessity to enhance these and other innovative elements promoted by metaphor, such as the dynamics of transformation and reconfiguration of cognitive and normative meanings, is expressed in the recent scientific literature: in Steen's deliberate metaphor theory (2015); in Prandi's distinction between conventional and conflictual metaphors (2017); in Gola and Ervas' valorization of communicational aspects of metaphor (2016); in Amin's work on the role played by metaphor in the conceptual changes required in learning processes (2015), and in Kövecses' extended cognitive metaphor theory (2020).

On the one hand, these theoretical perspectives aim to enhance the relationship between the cognitive and the creative aspects of metaphor. On the other hand, they highlight the heuristic and innovative potential that metaphor can express within the linguistic and communicative dimension in which it is contextualized. Aesthetics, as a discipline, offers many contributions in this direction: firstly, Aesthetics has always underlined the innovative role that metaphors

1 Cfr. Cameron (2003), Zabel (2015), Contini (2013), Fuchs (2015), Ervas, Gola, and Rossi (2017).

promote, especially in poetic and literary discourse; secondly, it has always valued not only the conceptual aspects related to metaphors but also the linguistic ones, by addressing the issue of the existing relationship between metaphor, knowledge, and innovation; thirdly, it has always delved into themes that involved different disciplines[2]. The field of Science Education offers an ideal space of intersection between cognitive and conceptual issues and a deepening of the aesthetic meaning of metaphor: both the relationship between the innovative and the knowledge-related aspects of metaphor and the role of language are very relevant aspects for the development of innovative Science teaching methodologies. In the new wave in narrative theory, narrative is no longer considered just a literary genre or a sequentially organized representation of events, but a complex tool for thinking (Herman, 2010). Drawing on these premises, Fuchs *et al.* (2018) underline the role played by the narrative context, and therefore by language, in the process of displaying the full cognitive and innovative power of metaphors:

"Narrative organizes image schemas, metaphoric projections, and conceptual and linguistic metaphors in terms of a network representing a sort of connective fabric. For this reason, the cognitive power of one metaphor depends on the way it is interconnected with the others and in how the thread is interwoven in the plot of the narrative". (Fuchs *et al.* 2018, p. 100)

The new wave in narrative theory focuses on the cognitive aspects displayed to create and understand stories, showing how it can force readers to modify the interpretative models on which they have hitherto relied. The highlighted aspects were particularly relevant for the design of the experimentation described in this presentation, implemented within the research project "Knowing through metaphors[3]". The design of the research, described in the following paragraphs, was therefore developed by paying particular attention to the narrative context in which the metaphorical devices were situated.

1. The Research Project "Knowing through metaphors."

The project "Knowing through metaphors" consisted of several different actions. After the implementation of the philosophical and aesthetical analysis of the semantic and conceptual innovation of metaphors, briefly described in the preceding paragraph, the research group designed the empirical phase. The research group[4] decided to focus on the narrative context in order to develop an approach that promotes the use of metaphors in Science Education and created two short narratives. The main reason that brought the research group to create short stories that focused on scientific contents is that narrative, as previously stated, is no longer considered just a literary genre or a sequentially organized representation of events, but a complex tool for thinking. In fact, complex cognitive dimensions are displayed in the process of understanding stories, showing how such process modifies readers' interpretative models of reality. Therefore, the design of the experimental phase was not limited to the development of metaphorical schemes that were coherent from a scientific point of view. Instead, it aimed to contextualize such schemes within a complex narrative frame. The research group designed such a frame to guide the conceptual understanding of metaphors, extend their inferences, and encourage the production of new metaphorical devices.

In addition to the narrative aspect, during the design of the empirical phase particular attention was paid by the research group to the communicative context in which the metaphorical narratives would be presented to the students. The interdisciplinary composition of the research group allowed the development of narratives in which the correspondence between the subjects of the metaphorical utterance would be effective both from a scientific and a communicative point of view.

2 For a deeper analysis of these aspects, please refer to Contini (2017).

3 "Knowing through metaphors" is an interdisciplinary research project (referred to as "FAR") funded by the University of Modena and Reggio Emilia and coordinated by the author of this contribution.

4 The interdisciplinary research group included the author of this contribution (Professor of Aesthetics), who coordinated the team, and other Professors and researchers of the University of Modena and Reggio Emilia: Tiziana Altiero, Professor of Biology; Roberto Guidetti, Professor of Biological Evolution; Maya Antonietti, Professor of General Didactics; Dr. Andrea Pintus, and the post-doctoral fellows Alice Giuliani and Lorenzo Manera.

The empirical phase aimed to verify, through a quasi-experimental design, the research hypothesis at the base of the project: whether or not the use of metaphors and narrative supports the acquisition of complex knowledge through the development of skills such as knowing how to manage complex content, understanding complicated implications, and activating new associations between different areas of knowledge. A further aim of the experiment was to verify if the narrative-metaphorical methodology fosters the mid- to long-term memorization of scientific concepts and the student's original reworking of the latter. The learning model developed by the research group was also intended to verify the students' development of skills related to problem-solving/posing and critical thinking. Finally, through the research carried out, valuable data were collected to verify the hypothesis that the teaching methodology tested also supported more effective learning processes in students with special educational needs.

The following paragraphs describe the phases that characterized the design of the teaching model, the implementation of the experimental phase, and the main results that emerged from the data gathered.

1.1 The First Meeting of the Experimental Phase

Both the design and experimental phases involved six classes belonging to the same School based in Reggio Emilia. Students from six parallel classes took part in the experimental phase: two from the fourth year of the primary school, two from the fifth year of the Primary School and two from the first year of the secondary school.

In each grade, one class acted as an experimental group and the other as control group. For the fourth-grade classes of the Primary School, the topic addressed during the experimentation was the evolution. For the fifth-grade classes of the Primary School and the first-grade classes of the Secondary School, the topic studied during the experimental phase was the structure of the cell.

The fact that all the students involved in the experimental phase belonged to the same institution[5] guaranteed a substantial level of homogeneity among the members of the experimental classes and the control classes, at least from the social and cultural points of view. In order to guarantee the absence of significant differences between the experimental and control classes in terms of previously acquired knowledge and level ofcomprehension of the texts, the researchers administered a pre-test during the first of the five meetings proposed for each class[6]. The results of the tests confirmed, for each pair of classes (control and experimental), the similarity of the starting conditions[7] and the consequent comparability of the experimental data

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1.2 The Second Meeting of the Experimental Phase

During the second meeting, an expert teacher engaged for the research project read and discussed, in the control classes, a traditional Science Education text[8], centered either on the concept of natural selection or on the structure of the cell. In the experimental classes, the same teacher read and discussed the metaphorical narratives developed by the research group. In both cases, the interaction between the expert teacher and the students were based on texts characterized by a similar length and the absence of images to guarantee similar conditions for the experimental and the control classes.

The narrative created for the fourth graders of the primary school was centered on the concept of natural selection in the evolution theory, deepened through the metaphor of the tree of

5 The *Istituto Comprensivo* (Comprehensive Institute) "Leonardo Da Vinci", based in Reggio Emilia.

6 The meetings dedicated to the experimental activities took place between January2020 and October 2020.

7 I.e., skills related to the comprehension of narrative texts and the existing knowledge related to the topic of the experiment (either the evolution theory or the structure of cell).

8 All the texts have been validated by members of the research groups.

life. In the story, titled "Gea, the young whale"[9], the tree of life is represented by a real coral tree, directly observable and explorable.
The plot chronicles the journey of a blue whale named Gea, who is looking for explanations about her origins. In the journey, Gea is accompanied by her grandfather to explore a large tree with many branches that intertwine and stretch up and in all directions. By exploring the tree, Gea begins to understand the process that drove the evolution of many different species that preceded her:

> *Gea*: is this a tree? Like the ones you find on islands?
> *Gea's grandfather*: I didn't think you had ever seen one! This is a special tree, different from all the others. It is very, very old...much older than me! It took it millions of years to become the way you see it now.
> It slowly grew into a trunk, which gradually split, generating the branches that are now bigger; these, in turn, have generated other branches, which become thinner as they go upwards.
> *Gea*: And all those tiny green dots...what are they?
> *Gea's grandfather*: Those tiny green dots are called leaves. Take a good look at them, Gea! Even though they belong to the same tree, they're not the same! We can say that they are similar and yet different! Some are big and open, some are small and closed, and some are emerald, green. However, as we climb higher, the branches become thin, and the leaves are lighter and smaller. They are all are part of the great tree of life[10].

This excerpt allows us to analyze one of the many metaphors contextualized in the story. In this case, the analogic correspondences concern the characteristics of the tree of life and the aspects that define the species evolution theory.

Table 1. Examples of analogic correspondences emerging from the evolution-tree of life metaphor.

Species evolution	**Tree of life**
Originated from small organic molecules	Originates from something small (seed)
The species become more numerous over time	The branches become more numerous over time
Species can become extinct	Branches can break off
Each individual of a species is similar but unique	Leaves are similar but all different
Evolutionary events are not predictable	Each branch takes an unpredictable direction

The encounter with the ancestors that takes place during the journey highlights two further concepts. Firstly, the idea of continuity with the past is enhanced by highlighting the similarity of contemporary individuals to certain qualities of distant ancestors. Secondly, the awareness that there are variations, ruptures, and discontinuities[11].

The narrative created for the fifth graders of the primary school and the students of the first grade of the middle school involved in the project was centered on the structure of the cell.

9 The story is inspired by Dixon and Bailey (2018).
10 Excerpt from the story "Gea, the young whale", created by the research group.
11 For example, attention is drawn to an "anomalous" characteristic that becomes an evolutionary advantage and thus replaces previous characteristics over time, setting the conditions for a species renewal.

In the story, titled "Welcome to Ellulandia!"[12], the Science teacher takes his students to a special room in the school, where they find a microscope that becomes the gateway to a fictional world, called Ellulandia[13], that can be visited with a submarine. While exploring the fictional world of Ellulandia, the students meet several characters, and while the teacher explains what is happening, they begin to understand several aspects of the structure of the cell, such as the role performed by enzymes:

> *Teacher*: Here in Ellulandia, there are so many enzymes, billions and billions. There are many types, and each one can do something different from the others... but not only! They perform their actions quickly and precisely: just think that each enzyme can perform up to a thousand actions every second.
> *Student*: This means that they are... robots!
> *Teacher*: Well, let's say that they look like robots...but they are not made of iron and circuits, but of a different material, a "biological" material. They are bio-robots[14].

In this excerpt, the analogic correspondences concern the characteristics of the enzymes and the biorobots, which are analyzed in the following table[15].

Table 2. Examples of analogic correspondences emerging from the enzymes-bio-robot metaphor.

Enzymes	**Biorobots**
Enzymes are degradable	Biorobots are biodegradable
Follow the instructions of the DNA	Follow the instruction of the programmer
Enzymes are very efficient in the catalytic process	Biorobots are very efficient in performing the actions they're programmed for

By reading and discussing the narratives together, the young students involved had the possibility to engage with the metaphors actively and critically. Both in the experimental and the control classes, the expert teacher who conducted the meetings interspersed the exposition of the text contents with moments of reflection and re-elaboration, aimed to support the students' involvement[16].

1.3 The Third Meeting of the Experimental Phase

The texts were read and discussed in all the classes involved during the second meeting and the first part of the third meeting. In the second part of the third meeting, the expert teacher administered the post-tests to the students. The post-tests, designed by the research group, consisted of a mix of multiple-choice questions and open-ended questions. For the fourth graders, questions focused on the topic of the Evolution Theory. For the students of the fifth grade of the Primary School and the students of the first grade of Secondary School, the questions

12 The story is inspired by Monaco and Pompili (2012).

13 The fictional world visited by the characters in the story is intended to simulate the function of a theoretical model built to discover what the cell looks like and how it works.

14 Excerpt from the story "Welcome to Ellulandia!", created by the research group.

15 Several other metaphorical devices are present in the story, suggesting analogic correspondence between a fortress and the nucleus of the cell, the structure of the mitochondria and a power plant, the role played by the DNA and the role of staff chief, the membrane of the cell and the border of Ellulandia.

16 An external observer recorded all the experimental activities with a video-camera and audio recorder, to allow a qualitative analysis of the interaction that occurred during the meetings.

focused on the structure of the cell[17]. The tests were intended, on the one hand, to verify the acquisition of new knowledge and on the other, to examine the students' ability to re-elaborate the contents. In order to test this ability, the last part of the tests contained questions such as: "How would you explain the Evolution Theory/the structure of the cell to a friend of yours who has never heard of it?". The research group also analyzed the answers to these questions to identify the use of new metaphors in the students' explanation of the content, which will be discussed in the paragraph dedicated to the tests results.

1.4 The Fourth and Fifth Meetings of the Experimental Phase

For all the classes involved in the research, the fourth meeting included a workshop dedicated to a further reinterpretation of the contents presented during the previous meetings. The research group designed the workshop based on the STEAM Education paradigm (De la Garza & Travis 2019). This paradigm involves the interweaving of logical-scientific and artistic-symbolic languages, an intentional and designed use of the materials available to students. It is based on the opportunity to think critically about and truly understand conceptual content.

Because of the suspension of in-presence teaching due to the spread of COVID-19, the experimental and the control classes of the Secondary School participated in the workshop in-person. During the workshop, the students worked in small groups of four-five members. The teacher provided each group of students with drawing materials and asked each group the answer the question "How would you represent the structure of the cell to a friend of yours who does not know it?". Due to the Covid-19 pandemic, for the fourth and fifth graders of the Primary School the workshop was organized online. The teacher asked the students to create a drawing related to the content presented during the previous meetings. In particular, the teacher asked the fourth graders to create a drawing linked to the question: "How would you represent the Evolution Theory to a friend of yours who has never heard of it?". In the workshop for the fifth graders, the teacher asked the students of the fifth-grade classes to create a drawing linked to the question: "How would you represent the structure of the cell to a friend of yours who does not know it?".

During the fifth meeting, which took place via videoconference two months after the workshop, the teacher administered a follow-up test to the students. The follow-up test had the same structure of the post-test, and its purpose was to collect data on the differences between the students in the experimental and control classes in terms of long-term knowledge acquisition. The research group gathered further data on the long-term knowledge acquisition related to the topic of the experimentation by administering a second in-person follow-up test five months later[18].

2 The Results of the Experimental Phase

2.1 The Results of the Experimental Phase in the Middle School

Several interesting aspects emerge from the quantitative and qualitative analysis of the data gathered through the tests administered in the first-grade classes of the Middle School. Firstly, we notice that on the pre-test, the experimental and control class students did not show relevant differences in terms of pre-existing knowledge[19]. However, if we look at the post-test results, we can see a significant difference between the results obtained by the experimental and the control classes in their responses to the questions about the parts of the cell.

17 The control class of the fifth grade, due to the suspension of teaching activities in presence related to the Covid-19 pandemic, held the third meeting via videoconference.

18 The research group proposed the second follow-up test only to the former fourth graders and first graders, as the fifth graders had moved to the Middle School.

19 The difference between the scores reached in the experimental and control class in terms of correct answers does not overcome the 15%.

Table 3. Percentage of the students who answered correctly to the post-tests open-ended questions

The topic of the question	Percentage of the students who answered correctly in the experimental class	Percentage of the students who answered correctly in the control class
Structure of the cell	96%	96%
Ribosomes	38%	12%
Cell membrane	71%	58%
Mitochondria	42%	27%
Enzymes	58%	35%

Secondly, in the analysis of the answers to the open-ended question, the research group considered the presence of metaphors in the answers provided by the students of the experimental class[20]. The analysis showed that a significant percentage of students (40%) used metaphors[21] in at least one of the answers. In the answers to the question concerning the structure of the cell, the metaphor of the planet was the prevalent one. Instead, in the description of the cell membrane, presented in the narrative through the metaphors of "skin" and "border", in the answers to the question was described by using the concepts of "cover", "protection" or "filter". Other metaphors emerged in the answers: the cell membrane was also associated to the image of a "protective shield", and to the earth's crust, a further articulation of the planet model. In the answers to the question concerning mitochondria, the metaphors used were inspired by the one already presented in the narrative, which described them in terms of batteries. In the answers to the question concerning enzymes, on the one hand emerged the metaphor of the specialized workers, already present in the narrative. On the other hand, new connections emerged, for example in the answers in which the enzymes were presented as wound-healers or handymen.

If we consider the presence of metaphors in the experimental class follow-up tests, the element that emerged from the analysis is that the students used fewer metaphors to answer the question and instead provided more descriptive information. For example, in the question related to enzymes[22], the percentage of students in the experimental class who used metaphors in the post-test was 82%, in the follow-up test 17%. At the same time, the percentage of students who responded to the question in the experimental class corresponded to 85%, while in the control class only 59% of the students responded. This element suggests that despite the decrease in the use of metaphors in the follow up-test, the information processed through the metaphorical-narrative methodology was maintained in the medium term. If we consider the second follow-up test, administered six months after the first, what emerged is that the 14% of the experimental class provided poor or wrong answers[23]. In the control class, the percentage of students who provided poor or wrong answers was 50% of the students, a further element suggesting the efficacy of the metaphorical-narrative methodology for the acquisition and retention of knowledge.

20 In the answer provided by the control classes, only very few metaphors emerged, as the teacher read and discussed with them a traditional Science Education textbook.

21 For the identification of metaphors, the research team adopted as a reference the generic definition of metaphor proposed by Lakoff and Johnson (1980, p.5), intended as "understanding and experiencing one kind of things in terms of another".

22 "What are enzymes, and what is their role?"

23 A further relevant element is that the two students of the experimental class with special educational needs provided correct answers, suggesting the efficacy of the experimental methodology from an inclusive point of view.

2.2 The Results of the Experimental Phase in the Primary School

As anticipated, during the experimental phase the fifth graders of the Primary School, like the Middle School students, examined the topic of cell structure. The analysis of the pre-tests showed that the students of the experimental and the control class did not show relevant differences in terms of pre-existing knowledge. Due to the suspension of teaching activities related to the Covid-19 pandemic, the teacher administered the post-test and the follow-up to the control class via videoconference, and only very few students were present. For this reason, we will consider only the results of the experimental class, by comparing the data collected from the pre-test and the post-test[24], both administered in person.

Table 4. Comparison between the results of the pre and post-tests of the Primary School experimental class

Topic of the question	Percentage of the students who answered correctly in the pre-test	Percentage of the students who answered correctly in the post-test
Cell membrane	33%	65%
Mitochondria	18%	71%
Enzymes	6%	86%

By comparing the data from the pre-test and the post-test, on the one hand we can see an improvement on each item of the test. On the other hand, an aspect that stands out is that more than 50% of the students responded correctly to the questions in the post-test. This element suggests the efficacy of the experimental activities in terms of acquired knowledge. Regarding the presence of metaphors in the answers provided by the students of the experimental class, most of them were related to the cell membrane or the enzymes. For example, the cell membrane was described using the checkpoint metaphor, and the enzymes were described in terms of guards or handymen.

Further metaphors emerged from the drawings that the fifth graders of the experimental class created during the workshop, which took place online two and a half months after the post-test. The teacher asked each student to create a drawing linked to the question: "How would you represent the structure of the cell to a friend of yours who does not know it?". In the example that follows, we can observe how the different elements of the cell are represented metaphorically.

In addition to the creation of the drawing, the teacher asked the students to provide an explanation of its contents. In the explanation of the drawing shown above (Figure 1), the student wrote:

> "In this drawing I tried to represent how I imagine the cell. On the outside I drew the cell membrane. I imagined it as a wall, with doors at the bottom and top where only the necessary substances and organisms can enter. Inside the cell membrane there is a gelatinous sea, the cytoplasm. In the sea, we can find islands representing the mitochondria, where the energy distributed to the whole cell, called ATP, is produced (which I imagine as a battery).
> Furthermore, inside the cytoplasm I have drawn some boats with enzymes on them, which I imagine as handymen that move from one part of the cell to another by rowing. At the center of the cell, finally, we can see the nucleus. It is protected from the sea, and hosts the DNA, which I imagine as the king of the cell".

24 The follow-up test was also delivered online in the experimental class. Only a few students participated, preventing a comparative analysis with results of the post-test.

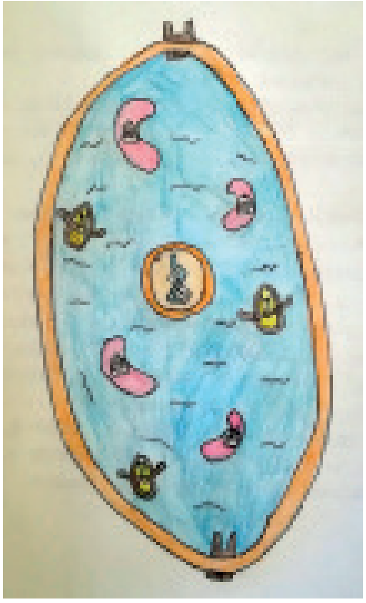

Figure 1. Drawing of the cell structure created during the workshop by a fifth-grader in the experimental class. The cell membrane is represented as a wall, the cytoplasm as a gelatinous sea, the mitochondria as small islands, the ATP as batteries, the enzymes as rowing handymen, and the DNA as a King.

If we consider that the workshop was proposed two and a half months after the metaphorical story was presented and discussed with the students, the drawing is a further element suggesting that the narrative-metaphorical methodology both supported the long-term acquisition of knowledge, and fostered personal and creative reinterpretations of the contents.

For the fourth graders of the Primary School, the experiment addressed the topic of Evolution. The results of the pre-tests showed that the students in the experimental and control classes did not show differences in terms of pre-existing knowledge, an element that strengthens the significance of the data gathered from the analysis of the post-tests.

Table 4. Percentage of the students who answered correctly to the close-ended questions of the post-test

The topic of the question	Percentage of the students who answered correctly in the experimental class	Percentage of the students who answered correctly in the control class
Tree of life	63%	33%
Extinction	47%	71%
Natural selection	36%	14%

The results of the post-test show that the students of the experimental class performed better in the post-test. A critical aspect regards the fact that the results show that in both the experimental and the control class the percentage of students who responded correctly is not high, an aspect probably due to the complexity of the topic addressed and the short time available for the presentation and discussion of the contents[25]. Other relevant elements of interest concern the results of the follow-up test administered six months after the post-test. In the follow-up test, the percentage of students who responded correctly remained similar, an element that suggests the long-term knowledge acquisition related to experimented method-

25 This aspect is confirmed by the analysis of the open-ended questions of the texts.

ology. Furthermore, in the experimental class two of the four students with special educational needs responded correctly to the questions. In the control class, only one of the five students with special educational needs responded correctly, a further element suggesting the inclusive dimension of the narrative-metaphorical methodology.

2. Conclusive remarks

From the results of the quantitative and qualitative analyses conducted it is possible to outline several elements of interest. Firstly, from the data gathered, the narrative metaphorical methodology applied in the experimental classes supported a deeper understanding of complex concepts. In fact, by reading and discussing the narratives together, the young students involved were able to engage with the metaphors actively and critically, reprocessing the scientific information addressed in the narrative. Secondly, if we compare the results of the experimental classes with those of the control classes, we notice that the narrative-metaphorical methodology better supported both the long-term acquisition of the information andthe inclusion of the students with special educational needs. Thirdly, the research results indicate that metaphors, when contextualized within narrative structure that facilitates their understanding and guides their implications, support the development of critical thinking. Finally, the results of the experimental classes, compared to the classes where traditional Science Education textbooks were used, suggest that the metaphorical narratives are more effective in activating new connections and supporting interaction.

Despite these promising results, some problematic features need to be underlined. In fact, the data gathered refer to a limited number of classes that took part in the research project. To further prove the efficacy of the experimented methodology, a larger data set would need to be gathered and analyzed. A further critical aspect concerns the design of the narratives, which ideally should integrate scientifically valid information with the elements that add an element of aesthetic pleasure[26]. To foster the dimension of aesthetic pleasure in the stories, the research group included elements such as the complexity of the characters, surprising events, and suspenseful situations. Nevertheless, further efforts need to be made in order to make the narratives more compelling. A challenge for future experimental projects consists of designing stories that are both scientifically valid and aesthetically pleasing. To achieve this goal, the integration of Sciences and Humanities is of the utmost importance.

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