THE STORY FORMAT AND THE CYCLE OF MEANING CONSTRUCTION FOR PHYSICS EDUCATION IN PRIMARY SCHOOLS

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Abstract

The story format may provide a stimulating environment, including tasks, questions or problems, giving space for scientific experimentation and group discussions guided by the teacher. In this contribution we present the main advantages of the story format for physics teaching and learning and the features that a story should have in order to implement what we call the "cycle of meaning construction", which constitutes an attempt to integrate the attributes already accredited to the story format in science teaching with pedagogical, methodological and didactic approaches. Lastly, a story will be presented in brief as a possible example for primary school physics education.

1. Introduction

In primary schools, the teaching of sciences is a delicate issue, both from the point of view of the children learning and that of the teacher teaching. We suggest and illustrate that a story, appropriately planned and implemented with a series of strategies and activities and supported by a planned methodological approach, may offer a powerful tool as a context in which children and teachers are supported in their needs. From children side a story, in fact, may give value to the baggage of imagination and creativity that the child brings with him/her and which the teacher may draw on. Moreover the story context gives to children the opportunity to find and to use ordinary words to express their ideas. Furthermore, the structure of the story in terms of experimental activities and didactic interventions based around disciplinary contents constitutes practical support for teachers and at the same time, it helps them to acquire skills in the planning and development of their own science curricula. In this article, we illustrate the features that a story should have in order to implement what we call the "cycle of meaning construction", i.e., to serve as a methodological support from the point of view both of the scientific disciplines and that of teaching. Lastly, the story "Rupert and the Dream of a Swimming Pool" will be presented as a possible example of application story features for primary schools.

2. The story as context to improve the cycle of meaning construction

Our interest here is limited to defining and systematising the characteristics that a story should have in proposing the story format as a medium for science education in primary schools.

The story turns around gaps, interruptions in which all children and teachers activities, related to the problem posed by the story, are inserted. There are gaps to allow for the imagination and reflection. "A story consists of narrated elements and of blanks and gaps" (Sternberg 1978). "Stories can tell the truth, but never the whole truth. (…) Gaps, on the other hand, must be left open to the imagination of the audience." (Kubli 2001).

Gaps may also be reinterpreted from a methodological and didactic point of view as interruptions to the story in which to insert children's and teachers' creativity and activities. The alternation between story and interruptions can help to intertwine the levels of logic and reality with those of thought and imagination, as well as encouraging the ongoing transition from one plane to the other. There are interruptions for experimental activities.

Experiments, according to the semiotic mediation framework (Corni 2011), are carried out using an instrumental approach. The experimental apparatus embodies meanings that pupils have to discover, stimulated by the task. The story supplies the tasks and it may concern artefact or embodied questions (Mariani 2011a). The choose of the task is a critic and important point. Although children find the motivation in a story for studying a given topic, how they then formulate good questions that drive the investigation phase may by no means be taken for granted. Particularly in the early years of primary school, children are not generally able to come up with scientific questions by themselves, so the story must guide the investigation process, asking the right questions in the right order. As far as the scientific investigation method is concerned, H. Fuchs (Fuchs, 2007) highlights that the process of construction of more or less formal scientific models of natural reality exploits interconnections that oscillate cyclically between posing questions

or problems, hypothesising solutions or foreseeing results, and planning experiments or experiencing: what he calls the four-cycle (4C) of hypotheses, questions, experiments and models. Suggesting the questions helps children to find their footing when faced with the other three stages of the four-cycle and, in the future, to learn how to formulate good questions independently. The child, stimulated by a contextualised question, construct situated texts (Bartolini & Mariotti, 2008) The "situated texts" produced by the children evolve to some form of "scientific texts" on the basis of the pupils' age (Mariani 2011b), fostered through the decontextualisation and recognition of analogies, thanks to teacher iterative didactic cycle (DC) that includes experimental activities, the individual production of output (oral and written texts, drawings, sketches, gestures, gazes and sounds...) and group discussions (Bartolini Bussi, 1996).
The story in science primary school teaching constitutes an attempt to integrate the attributes already accredited to the story with the 4C approach and the DC of semiotic mediation. This integration leads to a recursive sequential structure which we might call "cycle of meaning construction" (CMC). The recursive structure is the following:

- Telling a segment of the story that focuses on a problematic situation
- Presenting the task through a question
- Formulating individual hypotheses (written texts, drawings, etc.)
- Discussing in a group where pupils come together on a number of shared hypotheses
- Experimenting
- Observating and individually interpretating (written texts, drawings, etc.)
- Discussing in a group under the guidance of the teacher in order to reach a common text
- Restarting the story with the overcoming of the problematic situation.

The CMC, by virtue of its integrating three levels, constitutes an example of didactic transposition, and serves as a methodological mainframe for the teacher.

3. Features of story format and examples from the story "Rupert and the Dream of a Swimming Pool"

Having set forth these premises, we shall now propose a list of features to be included in a story for science education. We illustrate them (roman number) and their direct application (roman number-a) to the story "Rupert and the Dream of a Swimming Pool" intended for 4th-grade pupils but may also be suitable for children in the 3rd and 5th grades. This story has been experimented in numerous classroom (Corni 2010; Pagliaro 2011; Sedoni 2011)

(I) Each character has aspects with which children can easily identify. The children's identification with the characters is necessary for their emotional commitment and attention. (Ia) The frog Rupert and Pico are positive characters and represent two sides of the figure of the researcher: the former sums up the typical personality traits and behaviour of a child; the latter, the more serious and calculated behaviour of an adult. Students may feel emotionally more drawn to one or the other or to both, depending on their own personal inclination.
(II) The story consists of a series of problematic situations which the characters must deal with and which draw in children's attention and arouse their emotional involvement (Casey 2004). Children are thus highly stimulated to marshal their intellectual abilities in the acquisition of new knowledge and skills. (IIa)The swimming pool cannot be filled, or it is placed in the shade, or it overflows: circumstances that force Rupert to move the swimming pool to different heights and different distances from the aqueduct supplying the water, through tubes of various lengths and of different bores, from three different taps to be found at different heights
(III) The circumstances created by the stories must be believable, yet the fantasy elements arouse children's imagination, attention and curiosity, serving to ensure that they may enter the imaginary world while exiting it just as easily. (IIIa) The story is set in a garden which could be real; the problematic situations are plausible and reproducible through real experiments using real apparatus; the funny or dramatic scenes refer to amusing situations that may occur in keeping with the laws of physics; the drawings are deliberately essential so as not to distract children and help them to focus on the elements to be considered in the study
(IV) Pupils' involvement in the resolution of the problems is necessary for the story to progress. They are directly called upon from within the story by the characters, who explicitly consult them and ask what should be done. (IVa) Pico addresses directly to the children through the screen and

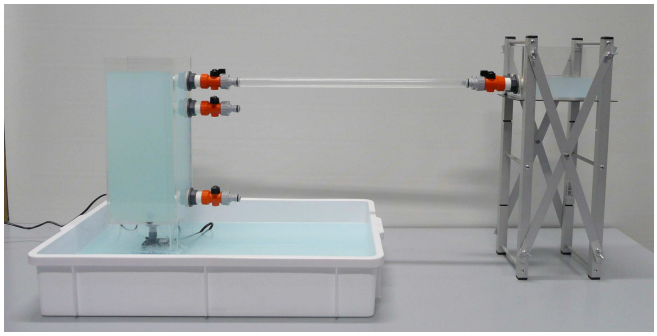
serves as a link between the fantasy world of the story and the real world of the classroom. Pico brings about this interaction by sending the children of the class a case with all the materials needed to carry out the experiments, and during the interruptions in the story he assigns tasks to be carried out and asks them to then send the results back to him; he stimulates group discussion with questions and suggestions, and makes himself available for personal contact with the pupils by e-mail

(V) The story features a great sense of aesthetics, harmony and order: all those qualities that come together to provide a familiar and serene atmosphere in order to place children in the best possible conditions for learning. (Va) The atmosphere of the story is created by both the narrative and the images.. The images are drawn by a children's illustrator (Arcadio Lobato) who, exploiting a form of beauty capable of arousing emotion, sets the atmosphere against a landscape with various shades of warm, intermingling colours.

(VI) Time is paced by logical events (problems and their solutions, causes and their effects, conceptual sequences, etc.), rather than by mere narrative events. For example (VIa) Rupert has to full fill the swimming pool connected to the aqueduct with difference in level between two containers and with or without inclination of the tube.

(VII) There are gaps to allow for the imagination, experimental activities and reflection (see paragraph 1.2) (VIIa) In "Rupert and the Dream of a Swimming Pool" Pico sent to the pupils the experimental apparatus shown in Fig.1. Questions, related to the semiotic uses of this apparatus, are posed by Pico inside the story to help children to discover that water can be transferred; water flows from higher to lower pressure (represented by higher and lower water levels); the pressure difference provides the push to drive the water through the tube (represented by a difference of water level); the balance corresponds to the condition in which the pressure levels are the same (same levels); the driving force is not influenced by the inclination of the tube.

Figure 1 shows the experimental apparatus sent by Pico to the pupils, set up as per the problems presented in story presented in "Rupert and the Dream of a Swimming Pool"



(VIII) There are gaps to insert teacher didactical cycle for for teacher-led discussions (see paragraph 1.2). There is a knowledge to be pieced together by the child under the guidance of the teacher in light of the various experimental and didactic activities proposed during the interruptions (VIIa). In order to make the didactic aspect more explicit, In Tab. 1 we list a number of pivot words (second column) extrapolated from sentences uttered by children during the pilot experimentations. The pivot words may, in turn, be placed in relation to meanings to be constructed. (third column)

Table 1: example of pivot words

Narrative steps related to logical events	Children's pivot words	Meaning to be built
…Rupert wants to find a suitable home for his future family. It must be welcoming and have a swimming pool on the top of the hill...	Tube, pump, glass, bucket. Fill, bring.	Water can be transferred.
…Rupert thought he might link up the swimming pool to a nearby aqueduct with a tube. But only a little bit of water ends	Aqueduct, tube. Upper level It has the pressure; it can	Water flows from higher to lower pressure (represented by higher and lower water levels).

up in the swimming pool...	go upwards.	
…Loretta gives instructions to lower the position of the swimming pool compared to the aqueduct…	Up to a certain level; the right level; equal. Lower tap, lower, faster.	The pressure difference provides the push to drive the water through the tube (represented by a difference of water level). The balance corresponds to the condition in which the pressure levels are the same (same levels).
…Now the swimming pool is in the right place, it fills up perfectly and the water level is always the same, even when Rupert spills some of the water over the side…	Running, reaching, overtaking, passing.	
…Rupert decided to connect the swimming pool to the higher tap, thinking that the favourable inclination of the tube would allow the swimming pool to fill up faster…	Faster. One is emptied and the other is filled. To overflow.	The pressure difference provides the push to drive the water through the tube (represented by a difference of water level). The driving force is not influenced by the inclination of the tube.
…Rupert decided to connect the swimming pool to the lower tap...	From low down upwards. It doesn't fill up. Manage to pass. The push for it to get through anyway.	

4. Conclusions

A story, put together with the features identified and presented here, may have a positive impact on the teaching/learning process. We wish to emphasise the importance of the story with its capacity to engage pupils both emotively and cognitively, interspersed with experimental activities and discussions led by the teacher, aimed at constructing scientific meanings.

The acquisition of the scientific method and of meaning construction skills are some of the key goals of science education. This is a very important aim considering that both the scientific method and meaning construction, in view of a future conceptualisation, are the fruit of a complex interconnection of specific cognitive tools, referred to as thinking and acting, as questions, experiments, hypotheses and modelling. This structure becomes even more complex if we consider that young pupils are unable to form scientific questions by themselves but must be taught to do so.

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