New Perspectives in Science Education
International Conference
NEW PERSPECTIVES in SCIENCE EDUCATION
Edition 4

The Nordic Physics Tale: a Travelling Scientific Dissemination Project Teaching Science to Children with an Artistic Approach.

Guillaume Dumazer[1], Aline Bruna[2]
[1]University of Oslo, [2]Nexans Norway AS (Norway)
[1]guillaume.dumazer@fys.uio.no, [1]guillaume.dumazer@hotmail.co.uk, [2]aline.bruna@nexans.com, [2]alinebruna23@hotmail.com

Abstract

An innovative experimental educational project was carried out in Norway in spring 2014. For three months, hundreds of pupils from 7 to 11 years old, who live in one of the most remote locations in Europe, have experienced a new method to appreciate Physics. The students attended a scientific fairytale performed on stage accompanied by experimental activities in classrooms. This project addressed the contemporary lack of interest in science observed in most developed countries, especially in Norway. This project had two reciprocal and challenging goals; using a fairytale as a media for scientific dissemination, and using scientific content to create a children's story.

By making use of a fairytale story happening in Norway, we attempted to bridge the gap between the common experiences of the everyday life and their corresponding physical interpretation. Fairytales are a familiar media for this audience. But how might a fairytale be used as a vehicle for physical ideas? We did this by employing the same mechanism that traditional fairytales use to impart morality. Physical phenomena were treated in a symbolical way which created opportunities to trigger scientific discussions with a young audience. Moreover, the fairytale was followed by experimental activities done by the pupils and linked to the story. The interest triggered during the performance was then kept alive, and further aspects of the scientific approach could be developed.

This project also aimed to provide stimulation towards science for children independent of their geographical location, not limited to big urban centers. We produced a nomadic project able to access remote islands, coastal and mountainous areas. This experiment has many areas that could be developed regarding science stimulation. Some of these include equality in science education regardless of geography, fruitful marriage between science and literature, enhancing scientific understanding in everyday life.

1. Introduction

The lack of interest toward sciences from the younger generations has been an issue in most developed countries in the last decades. This trend has been recently confirmed by large scale investigations over the scientific knowledge such as the survey PISA2012 [1], or TIMSS [2]. It's common to point out the limitations of traditional education systems. A quick review of unconventional science communication initiatives [3] led us to question the use of fairytale in science education.

Fairytales are familiar media from very young age. Their narrative structure gives space for implicit content, traditionally moralistic. Could a fairytale vehicle a scientific content? This challenge has been addressed during the project "Et fysikkeventyr fra Nord" [4] which took place in Norway during spring 2014. This was a travelling event aiming to tell a fairytale to children from 7 to 11 years old based on physical sciences.

A scientific fairytale has to follow some rules: on the one hand the style of traditional tale must be observed [5]; on the other hand the deeper scientific content folded into the narrative thread must be kept implicit. Communicating a message can be done under paradigmatic mode (traditional textbooks) or narrative mode (tales) [6,7]. Narratives naturally produce engagement of an audience both by avoiding technical language, and pushing the audience to look for what stands behind symbols.

The present work aims at suggesting a useful link between art and science for educational purpose, in line with previous experiment and studies [8,9]. Can a fairytale be used in science education? Can science be inspiring for creating a children story?

Most experimental educational measures are calibrated and first applied in big cities, before being spread towards more remote locations. We tried to operate differently by visiting in priority schools in remote places in Norway.

2. Our approach

The fairy tale creation was the first step in the project development. A balance had to be found between literacy and scientific content. We also considered important to include the following features:

the story happening in a Norwegian environment; the main character being a child and coming from another country (because of our French accent); the gender equality; the story developing as a quest. The fairytale was designed to be performed in schools and completed with experimental activities meant to develop the scientific concepts from the show.

2.1 The tale's summary

A young girl is on her way to look for her grandfather, an old Physics teacher who unexpectedly left home northwards. Unfortunately she got lost in a Nordic forest. She meets a moose advising her to use the pair of glasses lying mysteriously on a neighbouring stone. When looking at her watch with the glasses she notices that a compass needle has appeared and gives her the north direction.
She arrives next on the bank of a frozen lake. An elf is ice skating, training for figures. He only accepts to tell where the grandfather has gone if she trains with him. Because it's the first time she's stepping on a frozen surface she can't manage to skate properly. However, wearing the glasses once again helps her to perform a nice spinning. After detailing how her grandfather managed to row across the lake before it froze, the elf warns her about the ice's jaws which sometimes open. The glasses help the girl to locate these dangerous jaws.
The next obstacle is to climb a mountain covered by snow. Terrible deep sounds are coming. The moose appears behind the girl and mentions the legend of monsters inhabiting these mountains. Monsters are asleep just under the snow surface and can easily be awoken. If so, they become very angry and rush downwards swallowing everything on their path. The glasses help the girl to locate the sleeping monsters and she carefully avoids stepping on them.
The last part in this long journey is to cross the sea. Seagulls are flying easily back and forth and laugh at the wingless girl. Fortunately she finds a sailor about to leave. His boat is made of one hull and two wings. The sailor accepts to pick the girl up across the sea.
The girl finally arrives in the North. No tracks of the grand-father though. The moose arrives and asks the girl to help him removing his dress up. The girl recognizes her grandfather who explains the reasons for his escape. A school class of polar bears has sent him, by means of a sky lantern, a postcard where they beg for physics classes. He dressed up like a moose so that the girl could not recognize him and force him to go back home. He gave her the pair of glasses so that she was aware about the natural physical phenomena, potentially dangerous, and could reach the North.

2.2 Writing the scientific fairytale

The story begins in a landmark-less environment. The compass needle becoming visible with the glasses corresponds to the technique of using a watch as a compass. This is a consequence of the Earth rotation.
The story continues with physics of ice skating. An ice rink is a relevant model to illustrate fundamentals of classical mechanics such as velocity, acceleration, momentum conservation. The phase transition of the water which is part of the Norwegian curriculum in primary school and safety over frozen water are also approached.
The avalanches phenomenon was embodied by sleeping monsters, potentially dangerous if awaken. It illustrates the concept of "yield stress" in material sciences. The associated danger is suggested by the evil intention of the monsters.
Crossing the sea with a boat equipped with wings is a poetic way to illustrate Bernoulli Effect in fluid dynamics. The image suggests the similarity between air flow round bird wings, producing a vertical upwards force, and the air flow round one sail, producing a horizontal pulling force.
The concluding scene provides the looping end of the story. We introduced there one final phenomenon with the sky lantern used to carry a message. A sky lantern is an aesthetical object illustrating ideas in thermodynamics.

3. Context and practical aspects

A total of 68 school classes in 17 schools over 7 counties, in small towns as well as in remote locations (islands, northern parts of the country, mountainous locations) have been visited from March to June 2014. During this project more than 850 pupils have got there first physics course. Our educational project had to fit with the requirement of portability in moderate resources conditions along the 2 000km of the country. The scenery settings were meant to fit in classrooms and consisted in: a windbreak in natural material dividing the stage and the backstage; a white fabric forming a screen; a video projector; a music player; two chairs. Two actors were acting: one for the child character and one for all the secondary characters. This light-equipped show obtained a better impact when it was

performed as planned in the intimate atmosphere of classrooms, rather than on large stages, music room, or gym hall.
A bilingual French-Norwegian website and blog [4] was describing the project and updated with the project's progress.

4. Experimental activities

After the show, we had a discussion with the pupils and asked them if they had identified some physics or natural phenomena during the fairytale. Following this transition, a more traditional teaching session was meant to explore in detail the physics phenomena. We choose to focus on avalanches only since most of the Norwegian population is concerned. The experimental activities were inquiry-based and led across the steps of the scientific method summarized in the tables 1 and 2. This scientific method was framed by questions and scientific activities aiming at developing knowledge on snow and avalanches.

<table>
<tr><th></th><th>QUESTIONS</th><th>SCIENTIFIC ACTIVITIES</th><th>KNOWLEDGE DEVELOPED</th></tr>
<tr><td>1.OBSERVATIONS</td><td>- What are the different types of snow?
- What is an avalanche?
- Which type of snow will create avalanches?</td><td>- State-of-the art on snow and avalanches from general knowledge.
- Forming an ideal snow crystal with a piece of paper.</td><td>Main types of snow in snow crust:

- Fresh snowflakes (with symmetries)
- Fragmented particles
- Rounded grains
- Cup-shaped crystals (sugar snow)
- Wet grains</td></tr>
<tr><td>2. MODELLING</td><td>- Why do we have avalanches in the nature?
- How could we model an avalanche in classrooms?
- Which material could we use to model the fresh snow or the cup-shaped crystals?</td><td>- Imagining material to mimic different snow types.
- Imagining the preparation and the triggering of an avalanche.</td><td>Modelling avalanches processes:

<table><tr><th>Natural objects</th><th>Modelling</th></tr><tr><td>Fresh snow</td><td>Flour</td></tr><tr><td>Cup-shaped</td><td>Sugar</td></tr><tr><td>Clouds</td><td>Kitchen sieve</td></tr><tr><td>Mountains</td><td>Shoe Box</td></tr></table></td></tr>
</table>

Table 1. Experimental activities on avalanche processes – Steps 1 and 2

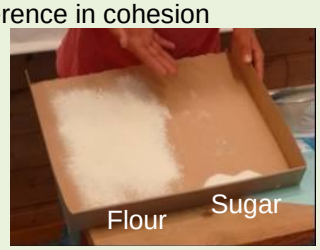
	QUESTIONS	SCIENTIFIC ACTIVITIES	KNOWLEDGE DEVELOPED
3. EXPERIMENTING	- Which material will be more cohesive? - How to compare their cohesion?	- Manipulating the experimental material: ✓ Experiment 1: Spreading one side of the shoe box with flour and the other with sugar (using kitchen sieve). ✓ Experiment 2: Spreading one layer of flour, one layer of sugar above, and another layer of flour on top - Observing results when slowly tilting the box. - Discussing with co-workers (groups of 2 to 4 pupils)	- Experiment 1 result: Relative difference in cohesion  - Experiment 2 result: Reproducing a typical slap avalanche 
4. CONCLUDING	- Does the model reproduce natural phenomenon? - How to develop the experiment? (effects of trees, change of slope, etc)	- Communicating observations to other groups - Comparing the results of the Experiment 2 with real observations from the nature. - Proposing development of the experiment	Real slap avalanche in multi layered snow crust with different cohesions: 

Table 2. Experimental activities on avalanche processes – Steps 3 and 4

5. Results and perspectives

Children's reactivity observed after the show confirmed the idea that a performed fairytale helps to transfer scientific knowledge. Indeed, the implicit scientific content in the story was surprisingly decrypted by some pupils. The jaws of the frozen lake being as ice fractures, awoken monsters rushing downwards in snowy mountains standing for avalanches, identification of the pupils' audience with the school class of polar bears are some examples. One class has been able to identify the momentum conservation performed on the ice-skating scene. We were accelerating our spinning by approaching our bodies.

It was interesting to note that at this age there is no clear distinction between the different fields of sciences (physics, chemistry, biology, etc.).

Qualitative results have been obtained after analysing reactions of the learners as well as listening the comments from teachers. Post-event questionnaires have been sent, with one part dedicated to children's feedback, see table 3, and one part for teachers only. After few days, children were still able to remember the tale and reformulate the scientific concepts described in the scenes.

1. Which physical phenomena did you see in the tale?	2. Could you give other physical phenomena from the everyday life?	3. Where can we make physics experiments?
“avalanches”, “different phases of water”, “flying with wings with help of wind”, “stream of the water”	“the gravity”, “the northern lights”, “thunder or lightning”, “Earthquake”, “volcanic eruption”	“outside”, “in the nature”, “in a laboratory”, “in a classroom”, “at home”, “everywhere”

Table 3: Results from questionnaires – Children’s feedback

On a longer term it would be useful to reproduce a survey after some months.
The use of simple experimental material taken from the everyday life (sugar, flour, shoes box) illustrated the ubiquity of physics, experiments being possible in classrooms, at home, etc. Teachers mentioned the advantages of experimental activities obtained from easily available material, without the need of sophisticated equipments. Pupils were directly in contact with matter and experimented themselves. Moreover the usual teaching hierarchy with its one-way flux of knowledge, concepts, reasoning, etc. was balanced here by our medium command of Norwegian language. In this situation we were the experts in Physics but the pupils were the experts in language. This pushed them to take an active part in the learning session by producing the right formulation (from the key-words and concepts we suggested them), favouring their ownership on the knowledge and processes introduced. We also noted that in larger cities children seem to receive more stimulation towards sciences and had higher expectations about our visits. Our best results were obtained in small places.
This project is an experiment exploring an innovative way to educate children about sciences, mediated by artistic creation, and pointing at sciences in the everyday life. Using a scientific fairytale as a media for communicating scientific knowledge to a young audience has appeared to be helpful to trigger discussions. The performed story actually offered a matter, shared between teacher and learner, to talk about physical phenomena in the Norwegian nature.
Exporting the project in other European contexts could give information regarding the influence of cultural environments. The development of similar initiatives in other European countries could rely on groups practicing teaching methods involving art [10,11].

References

[1] OECD (2014). PISA 2012 Principaux résultats de l'Enquête PISA 2012. Paris: OECD Publications. http://www.oecd.org/pisa/keyfindings/pisa-2012-results-overview-FR.pdf
[2] Martin, M.O., Mullis, I.V.S., Foy, P., & Stanco, G.M. (2012). Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Boston College.
[3] www.paris-montagne.org
[4] www.fysikkeventyr.no
[5] Nikolajeva, M. (2003). Considering the Kunstmärchen: The History and Development of Literary Fairy Tales. Marvels and Tales. Vol. 17, 138-156.
[6] Avraamidou, L., and Osborne, J. (2009), International Journal of Science Education. Vol. 31, 1683-1707
[7] Kubli, F. (2001), Science and Education. Vol 10, 595-599.
[8] Ødegaard, M. (2003), Studies in Science Education. Vol 39, 75-102.
[9] Ødegaard, M., Haug, B., Mork, S., Sorvik, G., O. (2014), International Journal of Science Education, DOI:10.1080/09500693.2014.942719.
[10] ytouring.myresourcecloud.net/
[11] renaud.natacha.free.fr/montheatre.htm