STUDENT TEACHERS WRITING SCIENCE STORIES: A CASE STUDY

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Abstract: In the following, we will present a few case studies of stories for science education. These were prepared by student teachers at the end of an elective laboratory course (16 hours) that focused on stories and followed the mandatory Fundamental Physics and Laboratory course (50 hours) at the University of Modena and Reggio Emilia. Both courses are based upon structures of figurative thought used in everyday language that even young children make use of. The structures referred to are found in the Force Dynamic Gestalt of natural forces such as heat, water, wind, electricity, chemicals, or motion. Cognitive linguists have identified image schemas which can be projected metaphorically upon particular phenomena, which then generate abstract concepts. The same structures figure prominently in the formal science of physics, allowing us to apply the power of natural language and narrative forms of science to comprehending nature.

In this paper, we will investigate the hypothesis that allowing student teachers to write science stories for primary school is analogous to physics students creating and executing experiments. Although the results of this study may be qualitative and limited to a few stories, they demonstrate that story writing is indeed a powerful tool for professional development. Moreover, they support the notion of the narrative character of science teaching and learning. They open new perspectives for science curricula for primary school and an interdisciplinary approach to learning science and language.

Keywords: primary school teacher training, narrative science, stories for science education, force dynamic gestalt

INTRODUCTION

Teaching science to children in primary school and to student teachers are deeply related challenges. In order to make the training of primary school teachers more effective, we need to consider how a child's mind approaches nature. In the early years of primary school, children have not yet mastered reading and writing and cannot rely on the usual tools of literacy. They have a *mythic* understanding (Egan, 1988) which is similar to that of people in oral cultures who grasp their world in terms of gestalts of forces of nature.

Fuchs (2007) has identified a basic gestalt (called *Force Dynamic Gestalt* or FDG) that is based on cognitive linguistics (Croft & Cruse, 2004; Evans & Green, 2006). This is a foundation for scientific understanding derived from mythic culture. It is structured mainly in terms of three schematic aspects used for understanding complex psychological (fear, happiness, pain), social (justice, the market), and natural phenomena. By metaphoric projection, these schemas lead to fundamental abstract concepts that can be applied to explain (natural) phenomena: *fluid substance*, *vertical scale*, and *force* or *power*. The *image schema* (Johnson, 1987) of fluid substance leads to the notion of an amount or quantity and is related to the scientific concept of *extensive quantity*. The image schema of (vertical) scale structures intensity and corresponds to the scientific concept of *intensive quantity* or generalized potential (it is derived from the perception of polarities). Finally, the schema of force summarizes various simpler schemas of direct manipulation (Lakoff & Johnson, 1980; Talmy, 2000) and is related to *causation* and the scientific concept of *energy*.

In addition to these three basic aspects, there are other image schemas in the structure of the FDG. In physics and chemistry, each of the gestalts of forces (fluids, electricity, thermodynamics, gravity, linear and rotational motion, chemistry) obtains its proper extensive quantity (volume, electric charge, entropy, mass, momentum, spin, amount of substance) that accumulates in containers (materials, bodies); the quantity flows through the boundaries of the container driven by a negative difference of the conjugate generalized potential (pressure, voltage, temperature, gravitational potential, velocity, angular speed, chemical potential); the scientific concept of *capacitance* relates to the way in which the potential increases when the extensive quantity accumulates in a container; and *resistance* relates to the way in which the potential difference grows in order to increase a current. In this framework, science education consists of helping children to recognize, differentiate, and apply the various aspects and schemas of a force. Basing conceptualizations of natural processes upon image schemas in general and upon the figurative structures of the FDG in particular, is expected to provide a solid grounding for primary school science (Fuchs, 2013a; Corni, 2013a). It allows for a direct approach to a narrative form of science education suitable for young children. Stories are therefore a good tool for teaching science to young children (Corni, 2013b).

If student teachers learn to apply good natural language to the gestalt of forces and if they are reassured that they possess the power of thought reflected in that language, they will become inclined to believe in their ability to be good narrators of things happening in nature. In stories, the *story schema* (Mandler, 1984; Egan, 1986, 1988), underlying narrative understanding, combines with the *character schema* of the gestalt of natural forces (wind, fire, water, chemicals, light, food, motion, etc.) to create a world easily understood by children of various ages (Fuchs, 2013b). Children who are learning to think and speak about human affairs—thereby combining the structure of story schema with a feeling for the characters of social and psychological forces—are expected to learn about and understand the characters of natural forces.

In stories for the youngest children, we start by putting emphasis upon the story schema with its power to engage affective understanding (the drama of humans or animals that experience natural forces). Then, as children grow, we can let the characters of forces of nature with their aspects of intensity, quantity and force/power, step from the background into the foreground, slowly leading to more formal narratives.

In this paper, we will outline the structure and the contents of a pre-service teachers' course in physics based on the concepts described here. We will also report on analyses of stories created by the student teachers themselves.

HYPOTHESIS AND RESEARCH QUESTION

We will base our investigation upon the following assumption: For student teachers, the task of developing a story for science education for the early years of primary school is equivalent to giving a physics student the task of planning and executing an experiment. Both activities require methodological and conceptual skills, one in the professional context of science education, the other in physical research.

The goal of this investigation is to demonstrate *how student teachers trained in the framework of forces of nature deal with the experimental task of writing good stories for science education*. This task will be accomplished: i) by evaluating the stories produced by the students at the end of the course, and ii) by analyzing the students' answers to a questionnaire given one year after completion of the didactical activities.

STRUCTURE AND CONTENTS OF THE COURSE

The course addressed prospective primary school teachers (second year of the degree in Primary Education) in the first semester of the 2011-2012 academic year at the Department of Education and Humanities of the University of Modena and Reggio Emilia.

There were various didactical activities connected with the course (76 hours in total).

Physics lessons

A physics course (Part I, 30 hours, attended by about 60 students) was taught using the approach afforded by the aspects of the Force Dynamic Gestalt (quantity, intensity, force/power)

These aspects span various topics of physics and form the basis of our metaphorical understanding of forces of nature.

The topics were:

- Figurative thought, image schemas, FDG of natural forces and metaphorical projection;
- Extensive and conjugated intensive quantities (extended potentials) related to a physical process, energy (balance between quantity and change in intensity among coupled processes in a cause-effect chain);
- Fluids, Motion, Thermal phenomena, Electricity, Chemical substances. For every phenomenon, the corresponding extensive (volume, momentum, entropy, charge, substance amount) and intensive quantities (pressure, velocity, temperature, electric potential, chemical potential) and their mutual relations

leading to the concepts of capacitance, resistance, current, and energy, were analyzed.

The goal was to supply students with simple concepts that are powerful enough to scientifically interpret everyday phenomena that might also be encountered in school.

Experimental activities

The second part of the course (Part II, 30 hours, attended by the same group of about 60 students) provided the introduction to measurements and error handling.

It also proposed some laboratory experiments, measurements, and (graphical) search for simple relations (linearity and proportionality) that were executed by students in groups of 4-6. In the last 8 of the 30 hours of the laboratory, methodological issues were covered and didactical activities designed which take the cognitive and linguistic skills of children aged 5-11 into account.

Exam

Afterwards, students prepare for the final (oral) exam by submitting:

- a summary of a lesson on the topics covered during a period of the first part of the course (group activity);
- a didactical unit about a physical argument using stories, experiments and general activities (individual activity);
- a story for physics education (individual activity).

Laboratory on stories

The last (optional and not assessed) part of the course (Part III, 16 hours, attended by 22 of the previous students) was a laboratory that was available to students after the exam, at the beginning of the second semester.

The students were personally involved in working with stories for physics education. After an introduction about the interplay between *story schema* (Egan, 1986) and *character schema* (Fuchs, 2013b) and the analysis of some case studies taken from the stories presented for the exam, every student was invited to:

- review and correct the story created for the exam and one created by another student;
- design a didactical unit around a given story (the course teacher gave the students a story about heat and asked them to design a didactical path for a primary school class, specifying activities, scheduling, materials, grouping, setting etc., and explaining every choice made);
- write a new story for the first years of primary school;
- discuss the new story with the course teacher;
- revise the new story according to the suggestions of the course teacher.

DATA

The stories analysed in this paper (section 5.1), 17 in total, were written by the student teachers at the end of the 16 hours of laboratory work (5 stories have been excluded from the analysis due to incomplete data). The requirement for the story was that it be suitable for young children (5-6 years old) and use the example of fluids.

To test the soundness and the stability of the course contents (disciplinary aspect – section 5.2) and the students' ability to use stories (methodological aspect – section 5.3), a questionnaire was given to some students one year after the course. It concerned two stories given to every student, the first was the one the student wrote at the end of the course (own story), and the second was a story written by another student (assigned story). For data homogeneity, we have assigned four stories selected among the available 17 ones.

For each story, the student had to explain:

- the science behind the story in more technical form (disciplinary aspect);
- class activities to be associated with such story (methodological aspect).

In total, 11 questionnaires were returned.

ANALYSIS

Stories written by the students at the end of the course

The criteria for analysis dealt with the various topics discussed during the course:

- *story schema*, with initial tension providing affective involvement, development of the story and a satisfactory ending.
- *character schema*, with expressions related to the FDG aspects of intensity, quantity and force/power of a force of nature
- elementary concepts such as container, current, and resistance
- appropriateness of the story to children 5-6 years old, taking into account the language, the length of the phrases and the presence of images.

We have analysed both the story as written by the student, and the revised story after discussion with the course teacher. For every criterion, we simply checked if it was present or not.

We present the story “Theodore the beaver” here as an example. This was an assigned story and one of the four selected stories. Table 1 reports the expressions in the story and their analysis according to the criteria above.

Table 2 summarizes the results (percentage of stories matching some main criteria) of the analysis of the students’ stories before and after discussion with the course teacher. We found that in every story, at least one of the FDG aspects is present (character schema), with an average of 1.5 aspects before and 2.1 after discussion with the course teacher.

Table 1

Correspondence of the "Teodoro il castoro" expressions and the analysis criteria.

Expression of the story	*Interpretation*	*Criterion*	
One day, beaver daddy asked Teodoro to help him add a new piece to the dam made of sticks, which delimited their territory, in order to make it safer.	Family affects House safety	*Story schema*	Affective evolvement
As Teodoro was adding sticks to the dam, he noticed that the water of the river, which had beenflowing placidly, suddenly became faster.	Increase of water velocity due to decrease of cross section	*Elementary concepts*	Current
"I begin to feel confined, Teodoro! And this makes me very agitated!", answered the water.	Increase of pressure due to increase of resistance	*Character schema*	Intensity
But after the dam was complete, there was no space remaining for the water. The river could hardly flow between the sticks and the mud. […] It (the water) went around, but did not succeed in crossing the dam.	Obstacle provided by the little passages	*Elementary concepts*	Resistance
Then a little explosion occurred… The Teodoro's family was woken up by a very loud noise: part of the dam had been swept away by the river!	Development of new phenomena (explosion, noise, collapse)	*Character schema*	Force/power
The next morning, however, Teodoro noticed that the water of the river had returned to its usual placid flow! […], but Teodoro had surely learned a lesson!	Equilibrium of natural phenomena after disequilibrium Teodoro learns how nature works	*Story schema*	Ending

Questionnaires (disciplinary aspects)

We have compared the concepts evidenced by the students to those we recognize as present in the stories. To better analyse the students' answers, we have considered some elementary concepts, as well as the aspects of the FDG. We consider the concept match (the student recognizes a concept we recognize in the story too), the concept mismatch (the student does not recognize a concept we recognize in the story), and the concept addition (the student mentions a concept we do not recognize explicitly in the story).

Table 2

Results of analysis of the students' stories, before and after discussion with the course teacher.

		% before	*% after*
Story schema	Affective involvement	94	100
	Development and ending	94	94
Character schema (FDG aspects)	Quantity	53	76
	Intensity	59	71
	Force/power	41	65
Adequateness	Natural language	100	100
	Length of phrases	100	100
	Images	59	94

Table 3 summarizes the results of 11 questionnaires concerning the students' own stories. We report the percentages of match/mismatch for every concept, normalized to the occurrence we recognize, and the number of concept additions.

Globally for all concepts, the match percentage is 85% (the mismatch percentage is 15%), and the number of concept additions is 4.

Table 4 shows the results of the assigned stories. The collected questionnaires concerned the following stories: "Teodoro the beaver" (4 questionnaires), "Cocci and Wind" (4 questionnaires), "The train unable to brake" (1 questionnaire), and "The planet Gelaldo" (1 questionnaire). One questionnaire was not returned. For statistical relevance, we include the first two stories.

Globally for all concepts (comprising those of the stories excluded from Table 4), the match percentage is 64% (the mismatch percentage is 36%), and the number of concept additions is 4.

Questionnaires (methodological aspects)

The activities to be associated with the stories proposed by the students have been classified according to the disciplines of the curriculum and according to their type. Table 5 reports the classification of the activities both for their own stories and for the assigned ones.

DISCUSSION

A previous study of the affinity of student teachers towards physics after this course (Corni et al., 2012) has outlined the growth of awareness (1) of their ability to understand and learn physics and (2) of the power of natural language and narrative forms of science for comprehending nature.

Table 3

Results of the students' answers about the concepts present in the own story.

		% match	*% mismatch*	*concept occurrence*	*added concept*
FDG aspects	Quantity	57	43	7	1
	Intensity	100	0	9	0
	Force/power	90	10	10	0
Elementary concepts	Container	100	0	2	1
	Current	100	0	1	1
	Resistance	50	50	2	0
	Diff. of intensity as a push	100	0	3	1

The results of the present investigation, even if qualitative and limited to a few students and their stories, concern the students' awareness and the ability to write and use stories to teach physics. The goals here are to develop the ability to write well crafted stories, and the ability to employ such a story by analyzing its scientific contents and planning didactical activities.

Ability to write stories

Table 2 shows that before discussions with the course teacher, but especially afterwards, the students' stories exhibit high percentages of the qualities considered in this investigation. In particular, the students are able to write stories using everyday language suitable for young children that also follow a story schema.

Everyday language and the story form are recognized by students as powerful and proper in teaching physics (Fuchs, 2013a, 2013b; Corni, 2013a, 2013b). This is important, because it is often believed that a scientific story has to use technical language and contain scientific experiments. Including such technical elements leads to rather unnatural stories.

The fact that every story contains at least one aspect of the FDG, as well as the average numbers of aspects present (1.5 and 2.1, before and after the discussion with the course teacher, respectively), means that the students are able to deal with forces of nature in a story form. No particular aspect seems to be preferred or easier for them.

Ability to employ a story

Tables 3 and 4 present the same information relating to the concepts recognized by the students in their own stories and in the one assigned, respectively.

Table 4

Results of the students' answers about the concepts present in the assigned story. Note that this table refers to two particular stories, so some concepts will be not present.

			% match	*% mismatch*	*added concept*
Teodoro the beaver	FDG aspects	Quantity	Not present		1
		Intensity	100	0	0
		Force/power	75	25	0
	Elementary concepts	Container	Not present		1
		Current	75	25	0
		Resistance	25	75	0
		Diff. of intensity as a push	Not present		1
Cocci and Wind	FDG aspects	Quantity	25	75	0
		Intensity	50	50	0
		Force/power	100	0	0
	Elementary concepts	Container	Not present		1
		Current	Not present		0
		Resistance	Not present		0
		Diff. of intensity as a push	Not present		0

The global match percentage is very high for their own stories, but lower for the assigned ones, even though they are good (85% vs. 64%).

This could be due to the fact that students knew their own stories very well, having designed and worked on them, as opposed to the assigned one, which was encountered only in connection with the questionnaire.

Due to the low amount of statistical data for the assigned story (the data for each story come from 4 students), we cannot prove any differences in answer distribution compared to the students' own stories: the data in the two tables is nearly consistent. The matches to the aspects of the FDG are the most reliable in Table 3 due to their high number of occurrences.

The data suggests that the students are more sensitive to the intensity and the force/power aspects, than to the aspect of quantity.

Table 5

Activities proposed by the students divided by reference disciplines and types of activity.

		Own story	*Assigned story*
Disciplines	Biology	5	0
	Chemistry	4	4
	Geology	2	1
	Language	3	1
	Physics	12	15
	Physical activities	2	2
	Social education	1	0
Type of activity	Discussion	9	3
	Drawing	1	1
	Experimental	16	14
	Play	2	4
	Didactical excursion	1	1

It is interesting that the students also refer to concepts not explicitly present in the story (4 added concepts, both for their own and the assigned stories). This can be interpreted to mean that the students perceive the story as an opportunity to expand the argument and to introduce other concepts related to the ones present in the story.

Table 5 shows that the students see their stories as an opportunity to propose various activities for different disciplines such as biology, social education, physical activities, as well as physics. This shows that a student attending this course feels the physics learned here is connected to all sciences and fields of knowledge, and that he/she will be able to design interdisciplinary didactical activities.

This is confirmed by the types of activities the students chose, which were not only the experimental, stereotypical ones for physics.

Rather, they demonstrate that physics education, and science education in general, needs to be relevant and within the reach of the children of that age.

CONCLUSIONS

Our intentions here are not to demonstrate that this course, which relies on figurative structures of thought and narrative forms of science, will teach students more and better formal science than other more traditional ones. This would necessitate more extensive investigations with a larger number of students involved and control groups. Instead, we want to determine whether students are able to produce good stories that are suitable for children and to plan activities useful for science education. Moreover, we wanted to see if these abilities are stable over time. Our analysis indicates that these questions can be answered in the affirmative.

Important information can be obtained once these student teachers actually have a class of pupils. This is not possible at the moment, but we can gain some indications from the tutors that followed these students during their apprenticeship in a class (about 50 hours of presence with the tutor). We reached three of these tutors and interviewed them about the students' didactical abilities. On a scale from 1 to 6, they give students at least a 5 for the following abilities: planning, using stories, conducting laboratory activities, conducting physical activities, designing drawing activities and games, conducting class discussions.

Although the data presented is limited to a case study, our research and development open new perspectives for science curricula in primary schools and allow us to anticipate benefits from an interdisciplinary approach to science and language learning. Moreover, our results can be a base for designing more extensive research aimed at introducing figurative structures of everyday language and applying the power of narrative forms of science for comprehending nature in the university courses for student teachers, as well as in continuing education courses for in service teachers (Mariani, 2013).

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