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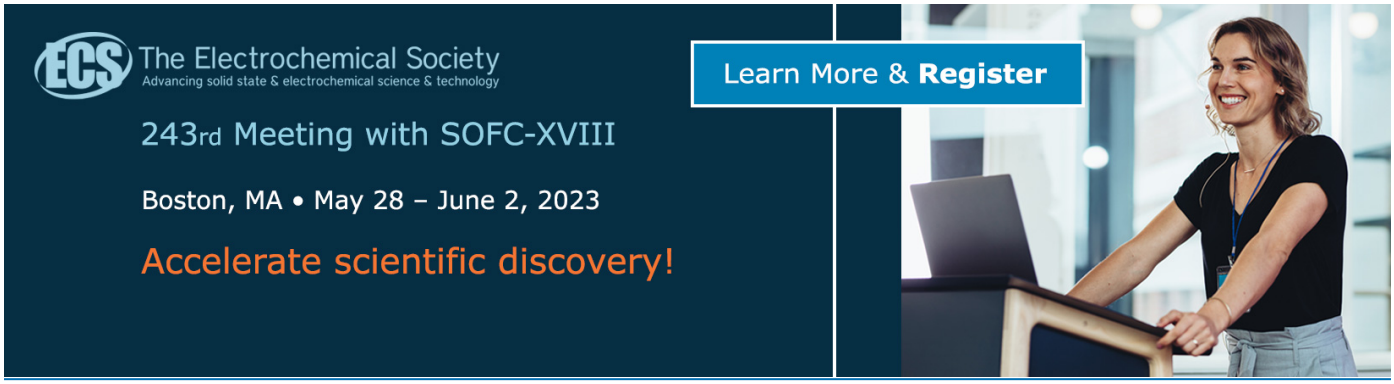

Didactic fairy tale designing as a key to proactive training of Physics and Mathematics at primary schools

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Abstract. Relevance of the selected research topic is due to its development results aiming to resolve contradictions between society's needs for personality-oriented training of Physics and Mathematics basics at comprehensive secondary school and the inadequate basic (necessary and sufficient) conditions to provide this in primary grades. Teachers also lack for a systematic and scientifically substantiated practice of immersing their students into the didactic fairytale environment. The research primarily aims to reveal the author's conceptual vision of the essence and principles of didactic fairy tale designing in order to convert it into a basic tool of Physics and Mathematics training to 1st – 4th grade pupils.

1. Introduction

First graders are in urgent need for fairy tales about mysteries of nature, in the School of Joy under the blue sky, which the Great Teacher Vasily Alexandrovich Sukhomlinsky masterfully revealed to them: "the Sun is scattering sparks. He lives high in the heavens. He has two Giant Blacksmiths and a golden anvil. Before dawn the Blacksmiths with their fiery beards go to the Sun, and he gives them two wisps of silver thread. The Blacksmiths take iron hammers; lay the silver threads on the golden anvil, and hammer away. They forge the Sun a silver garland, and silver sparks fly from the hammers and break into pieces, then fall all over the world. Sparks fall on the earth, and you can see them here. In the evening, the tired Blacksmiths go to the Sun and give him the garland. The Sun puts the garland on his golden braids and goes to his magic garden to rest." [1, p. 28].

It is a brilliant example of forming children's interest in learning about the natural world, their proactive nature-based training via a fairy tale. However, considering the age of the youngest pupils, their low adaptation to systematic intellectual work and school requirements, lack of required intellectual maturity, current background knowledge and academic experience to solve complicated problems, it is more relevant to speak about proactive training concerning not Physics, but natural sciences as this very subject is reflected in the curriculum of all elementary schools, this referring to first graders only.

The following basic components of the theoretical platform of our conceptual vision of creating the phenomenon of a didactic Physics/Mathematics-orientated fairy tale should be considered:

- the theory and methodology of teaching Physics and Mathematics at secondary schools;

- psychological foundations of the theory of proactive training as developing personality;
- theoretical principles on morphology and folk and author fairy tales' potential, their use for academic purposes;
- scientific ideas about psychology of creativity concerning two classes of creative tasks and peculiarities of solving the first-class tasks;
- the pedagogical technology of the project method.

2. Related work

The Soviet and post-Soviet periods of development of the theory and methodology of teaching Physics and Mathematics to schoolchildren, primarily in Russia, Ukraine and the Republic of Belarus, are characterized by a quite large number of studies on their problem areas.

Such authors of works on the theory and methodology of teaching Physics as A. N. Andreev, A. I. Arkhipova, P. S. Atamanchuk, T. A. Khannanova, S. Y. Kovaleva, G. G. Kordun, V. N. Maksimova, A. I. Pilipenko, V. T. Rykov, A. M. Sabo, V. V. Sagarda, O. R. Shefer, I. O. Teplytskyi, A. A. Tsokolenko, A. V. Usova, etc. consider various aspects of the problem of this process quality improvement [2–7]. While accentuating one aspect only (introduction of entertaining elements into the academic process, in particular, by means of digital technologies), one cannot but notice absence of a strategy that targets qualitative transformation of Physics training due to application of a didactic fairy tale in the suggested methodological approaches.

M. I. Burda, P. M. Erdniev, Ya. I. Grudenev, V. A. Gusev, V. M. Monakhov, Yu. M. Kolyagin, V. I. Krupich, G. I. Sarantsev, Z. I. Slepkan, A. A. Stolyar, N. A. Tarasenkova, A. Ya. Khinchin, M. B. Volovich, O. B. Yepisheva, and others make various components of theoretical principles of forming pupils' concepts and thinking modes via Mathematics resources their research areas on a retrospective basis [8–14].

Of all various relevant theoretical developments, we are particularly interested in those reflecting specific requirements of Mathematics for a pupil's personality, A. Ya. Khinchin being one of the first to reveal them. He believes that Mathematics calls for a pupil's thinking culture as the ability for full argumentation, i.e. to provide exhaustive general proof of statements, validity of analogies, achieve completeness of disjunctions, completeness and consistency of classifications. This famous mathematician and teacher associates culture of mathematical thinking with its style, variability, flexibility and creativity [15, p. 130-141].

Works by G. P. Bevz, V. G. Bevz, Ye. S. Dubinchuk, I. V. Yegorchenko, A. L. Zhokhov, M. I. Zaykin, L. S. Kapkaeva, L. V. Koval, M. G. Makarchenko, L .M. Naumova, V. V. Nikitin, O. V. Onopriyenko, M. A. Rodionov, K. A. Rupasov, S. A. Skvortsova, R. A. Uteyeva, and others are devoted to methodological aspects of forming concepts and action methods at Mathematics classes [16–19].

By no means all the results of methodological search of the listed and other authors are in conformity with the dialectical idea of the developing concept and conceptual philosophical and psychological principles of the cognition theory (traditional methods are based on classical logic). At the same time, especially in recent years, there has been a new positive trend of elaborating different versions of heuristic methods of teaching Mathematics.

The innovator-teacher S. N. Lysenkova is the first to suggest an idea of introducing small fragments of a new topic in the training process ahead of the time defined by the curriculum [20]. Practice confirms that implementation of this principle contributes to conscious perception and solid memorization of complicated training materials, accelerating formation of pupils' practical skills. The above idea is grounded upon the scientific and psychological doctrine by L. S. Vygotsky [21] about two levels of intellectual development of a personality (the level of current development at a given moment and the one defining the area of the nearest development).

These principles reveal the leading role of proactive training in personality development. They are elaborated in a creative way in L. V. Zankov's principles of developing training, and, in particular, reflected in high-complexity training, in the area of the nearest development of the pupil when playing a key role in learning theoretical knowledge and including emotions in the training process [22].

The process of creating a fairy tale for a child is to rely on the psychological mechanism of his/her imagination and its components defined by L. S. Vygotsky – dissociation (division of the whole into parts), change of dissociated elements (over/understatement) and association as their combination [21].

In searching for the conceptual scheme in question, V. V. Davydov's description of the contents and structure of the training developing activity that contributes to formation of schoolchildren's empirical and theoretical thinking is of great importance [23].

Elaboration of the conceptual scheme requires studying historical roots of the fairy tale and its morphology [24, 25]. V. Ya. Propp is first and foremost to describe the fairy tale in terms of its components, reveal their relations to each other and to the whole work, introduce constants (functions of characters and sequence of functions) and variables (the number and ways of performing functions, attributes and motives of characters' actions, a language style).

Gianni Rodari's *The Grammar of Fantasy. Introduction to the Art of Making Up Stories* is considered a valuable guideline for current and future authors of fairy tales as well as teachers and parents [26]. It is a rich treasury of not only methods to boost children's imagination and fantasy through literary works and techniques to write them, but also effective methods and tools to form their interest in creativity, readiness to compose fairy tales, poems and riddles.

Our conclusion that the problem of designing didactic fairy tales belongs to the first-class creative tasks (their solution does not require intuition, it is carried out on a conscious level) is greatly influenced by the results of analysis of monographs by Ya. A. Ponomarev. His *Psychology of Creativity* and *Psychology of Creativity and Pedagogy* deal with the psychological mechanism of an individual's creative thinking [27, 28].

In planning to rely on the project method, one could not ignore the history and theory of project development (J. Dewey [29], W. H. Kilpatrick [30], J. A. Stevenson [31], J. C. Raven [32], etc.). E. S. Polat reveals these issues in a high-level mathematical way [33].

3. Conceptual scheme

1. Physics and Mathematics are not only fundamental sciences, social advance drivers, objects of aesthetic pleasure that reveal strictness and elegance of their theories, results, beauty of the methods of proof, but also the main subjects of study in the educational system. The ultimate meaning of Mathematics' and Physics' beauty and social significance implies that they have an enormous personality-development potential. Primary school teachers start revealing this potential through changing pupils' basic activities from playing (at the preschool age) to learning at primary school, while play activity serves as a reference for the leading learning role.

Younger schoolchildren's development in a harmonious unity of sensual perception, empirical and theoretical thinking is promoted by pedagogical conditions created by various kinds of creativity and aimed to acquire emotional experience of basic physical laws, formulas, abstract definitions (given in textbooks) of the essence of concepts of Physics and Mathematics. It is about the idea of their figurative presentation, first of all, via visual, literary, musical and theatrical-dramatic arts, fragments of popular science films.

2. The phenomenon of a fairy tale plays a key role in the system of pedagogically appropriate products of literary (folk and author's) creative works. It is not only the first among others, but also the most vital for children's development in an existential context. Motivation for

the choice of prioritizing this phenomenon at primary school is essential for a conceptual vision of its potential as a key educational value and tool.

It is through a fairy tale that parents exercise their psychological and pedagogical support of their child's primary perception of the world, their son's or daughter's entry into his/her spiritual and moral space. It is very close to younger schoolchildren who already have experience of happy living in fairy tales and realizing their natural needs in fantasy, their value and semantic moral charge, high emotional and imaginative potential.

However, the main thing is that at the preschool age, fairy tales bring children even closer to their mother: when jointly immersed in a fairy tale plot, they always feel love of this very dear person, who can instantly answer some emerging questions and ask important ones. *The tale becomes associated with children's need for love.* As a result, at the level of consciousness and subconsciousness, their memory maintains warmth of love, which comes from the mother when revealing secrets of products of fairy tale creation (love radiates from her speech, facial expressions, gestures, happy laughter, kisses, and touches).

3. Emergence of didactic fairy tales of various functionalities designed for academic purposes to be used at primary and secondary schools of all levels as well as at higher educational institutions has become the peak of fairy tale evolution.

An author's didactic fairy tale is a literary work, either prose or poetry, which uses a fictitious plot (heroic, magic, natural and domestic) to reveal individual phenomena and specific laws of nature, elements of chemistry, biology and mathematics (calculus, elementary algebra, geometry, the theory of elementary functions and elements of analysis).

The author's spiritual and didactic fairy tale is a carrier of systemic values including higher human values and those of the main content of Physics, Mathematics, Chemistry, Biology and other subjects at comprehensive secondary school primarily in the conceptual and categorical dimension as it possesses appropriate fictional figurative (sometimes with a radically fantastic bias) tools to present them to pupils.

4. Spiritually didactic and purely didactic fairy tales are not guests, but full-fledged and basic tools of elementary school education, which should be fixed in the curricula in the form of a special integrative proactive course *Fairy Tale Lessons* (another title is also possible). It is about anticipating the timing of pupils' mastery of basic concepts of those sciences, the full study of which is planned at high school. The most important content area of this course is physical and mathematical.
5. The psychological mechanism of proactive training of Physics and Mathematics by fairy-tale tools includes the need-motivational and axio-acmeological components.

Pupils' emotional perception of the content of a didactic fairy tale, their readiness to reproduce physical and mathematical concepts as visual images are results of vivid reflection of these values in the literary work. It contributes to the psychological effect of infecting primary pupils emotionally, experiencing them as self-valuable, activating the mental mechanism of sense-making. All this is a signal to a teacher as a creator of conditions for pupils' development to be aware of the need to shift first to empirical and, later on, to theoretical types of thinking.

Physics and Mathematics proactive training at elementary school using a fairy tale is a potential source of a pupil's personal acmeological development. This process has two vectors of orientation:

1) the axiological vector aimed at increasing the value-based potential of the academic subject's personal axio-sphere and its enrichment with new developmentally strategic axiological formations;

2) the synergetic vector focused on pupils' awareness of the need to improve their own not quite structured life activity, self-organization of their training, in particular, the physical and mathematical one, and existence as a mature person.

6. Designing a didactic fairy tale of physical and mathematical orientation is a process of creating a pedagogical micro-model of figurative reproduction of a particular situation to manifest some general patterns of natural phenomena, features of properties and relationships of mathematical object elements as system entities based on attributing the magic status of communication subjects to material and mathematical objects, and introducing unreal fantastic characters in the plot.

In the systemic and technological aspect, didactic fairy tale designing looks like defining the architecture of a target pedagogical micro-model which covers scientifically grounded theses regarding explanation of literary-artistic and other solutions to a given academic problem. The model also includes its structural components and their functions, an integrity of methods, means and rules of interaction between them, some basic principles of the heuristic action aimed at creating this system-based work.

In algorithmic and operational terms, the main micro-stages of this process technology that reveal systemic features include:

- clarifying and realizing initial physical or mathematical data of the design problem set;
- choosing the most appropriate type of a fairy tale to be developed (either a transformational-heuristic on the basis of a known fairy tale or a holistic-innovative one);
- extracting and formulating a problem, ways and methods of ensuring the interrelation of scientific knowledge with figurative means of its demonstration;
- generating the main idea;
- finding optimal principles of building a heuristic literary and pedagogical search depending on the type of a tale created;
- developing the plot of the fictional part of the academic micro-model being guided by these principles and activating imagination and fantasy;
- synthesizing the structure (its scientific physical-mathematical and fictional imaginative-fantastical components);
- assessing and correcting the obtained synthetic model representation according to the criterion of its correspondence to the creative idea.

The main requirements for arranging the process of the didactic fairy tale design for proactive Physics and Mathematics training to primary schoolchildren are reflected in the following *principles*:

1) the principle of integrity of revealing physical and mathematical potential of folk and author's fairy tales to creatively transform them into didactic ones (the transformational-heuristic type);
2) the principle of creative freedom in changing plot elements of folk and author's tales (prologue, plot, collision, intrigue, peripeteia, climax, denouement, etc.), their plot schemes, expanding or choosing new characters in the main plot development of the narrative theme;
3) the principle of successive conditioning when selecting the scientific physical and mathematical content to create a holistic and innovative didactic fairy tale via proactive training considering pupils' age;
4) the principle of personality-development acmeological orientation of designing a holistic-innovative didactic fairy tale based on elements of scientific knowledge in the field of Physics and Mathematics;

5) the principle of strict subordination of story and plot fiction by the creator of a didactic fairy tale of all types (transformative-heuristic and holistic-innovative) to the strategy of proactive formation of pupils' knowledge of Physics and Mathematics basics.

4. Specific features and examples of practical implementation of the conceptual framework

Designing fairy tales of the first type has some peculiarities. It is up to their creator to choose one of the three options in this process guided by the principle of creative freedom:

1) in a new didactic work of the fairy tale genre, main characters of folk or author's basic tales known to children remain the same, only some elements of their plot change;
2) in the plot development of the narrative theme in basic fairy tales, either completely new characters act or the roles of old and new characters are combined;
3) the story line and the plot of folk or author's fairy tales as a special integrity become a means for pupils to discover some new elements of the academic content in proactive training in the system of their problem-search methodological presentation based on fairy tale motives (elements of the plot and the story line of the basic fairy tale become a platform for methodological development of a special lesson to disclose its educational potential).

4.1. Illustration of the first option

When designing, the first two action principles and the principle of strict subordination of the plot and story fiction to the strategy of proactive knowledge formation of Physics basics among third-graders are chosen as key ones. This plot element is changed in Charles Perrault's fairy tale *Little Red Riding Hood* as the denouement, in which Grandmother and her granddaughter remain alive, sit side by side, drink tea and remember the evil wolf. This fairy tale created by the author of the article is called *How Little Red Riding Hood and Grandma talked about the wolf's power*. Here is the extract from the fairy tale:

"... Little Red Riding Hood and Grandma drank some tea and started talking.

"The villain has tricked us, Granddaughter," sighed Grandma. "That's a shame. If you hadn't shown him where my house was, who knows how it would have turned out?"

"I'm sorry, darling," the girl almost cried. "No more shall I be deceived by tricky speeches of any deceitful and terrible beast."

Grandma looked approvingly at her granddaughter and said, "All right, Red Riding Hood. Be smarter from now on. And I, the old me, failed when I told the wolf how to open the door. He tricked me, too."

Little Red Riding Hood hesitated, looked at the door, and then asked, "Grandma, did nothing prevent the villain from opening your big thick door?"

"What are the locks for?" she asked. "They say different things about how I advised the beast to release the door from the locks. Whether the wolf pressed the latch or pulled the rope, but the result was the same: the latch bounced."

"And the door just opened, didn't it?"

"No, it didn't. It opens to the outside. The grey cheater must have pulled the door towards him. There's also a handle. And the wolf is a pretty strong animal. His strength is hidden in his muscles."

Little Red Riding Hood agreed:

"Yeah, my mom told me that both humans and animals have muscles. Here are my muscles, look how big they are! I tense muscles in my arm, and power builds up in them!"

"You are like a sparrow!" Grandma laughed and put Granddaughter's hand down. "The moment the wolf pulled the door handle toward him, his paw muscles contracted like the muscles

in your arm do. But here's the main thing: the beast's muscles brought both the wolf himself to the door and the door to the wolf with equal force."

"I don't quite understand, Grandma."

"In fact, there was not just one muscular force acting between the wolf and the door, but two forces," the old woman clarified. "The wolf applied the first one to the door, and the second one – from outside – was applied to his own body. And those forces were equal."

"So the door kept the wolf out, didn't it?"

Grandma took the girl by her hand, led her to the front door and said, "Look! We are standing in the wolf's place when he pulled the door open. His force was directed towards the yard that could be seen behind us. The force of the door, on the other hand, was directed in the opposite direction – towards my room."

"What if one would have to push the door instead of pulling it?"

"The wolf would have had to push it towards my room. Still, the force with which he would have done so would have caused a counteracting and equal force to his own. Only those forces would have pushed the beast and the door apart instead of bringing them closer together."

Little Red Riding Hood pulled the door open and suddenly turned to Grandmother.

"Some kind of the wolf's magical force. It turns out to be dual."

The old woman smiled and said, "In nature, all forces are dual. Whether an ant pulls a straw, or two rocks hit each other in the mountains. They are all examples of dual forces."

So, Red Riding Hood tried to conclude, "If a force acts on something (and not necessarily on a door!), there is always another force."

"This other force is equal to the first one and is necessarily opposite to it," Grandma concluded. "It's the law of nature."

"And yet it's a pity", Red Riding Hood remarked, "that this law didn't prevent the wolf from entering your home [34, p. 247–252]."

Little Red Riding Hood, Grandma and the wolf are the main characters of Charles Perrault's fairy tale. They are also dealt with in a didactic story based on the original one to illustrate the effect of Newton's third law. In revealing the didactic potential of the famous French storyteller's work, the fact of the wolf's *interaction* with the closed (and then opened) door of Grandma's house turns out to be the key one.

4.2. Illustration of the second option

When designing, the key principles include the first two action ones and that of strict subordination of the plot fiction to the strategy of proactive formation of third-graders' knowledge of Physics basics. We will focus on introducing third-graders to the secrets of solid-state fusion, formation of their understanding of the crystal lattice, the atom and forces of interatomic interaction based on the content of the folk tale *The Fox, the Hare and the Rooster*. Actually, the fact that in spring the fox's ice hut melted, and the hare's did not, is the most significant pivot for creating a new project. The old narrative theme with the red-haired rascal, the Hare chased out of his house, his rescuer Rooster are not mentioned anymore in Grandpa Didactic's fairy tale *How the Ice Melts, or the Story of the Ice Hut that can be Read in the Dwarves' Diaries*.

"... It was winter, when there were many, many days before spring, on the icy roof of the fox's hut the two dwarves, the Degree-Teller and the Heat-Teller, got acquainted and immediately felt a deep sympathy for each other. They quickly became friends bound by a common interest – they both loved to count all things related to the ice hut. How weird they were! They were not interested in the Fox's things at all. Even the chickens (the redhead did not forget to eat them even at home) did not attract the dwarves' attention. The Heat-Teller constantly counted the amount of heat that the Sun brought to melt the ice, and the Degree-Teller considered his duty

to establish the degree of the ice heated by the Sun's rays. Just like a thermometer measures the temperature of a sick person, he measured the temperature of the roof.

Every evening the friends used to share their recent measurements with each other. Together they wondered, got upset when the temperature and heat stopped rising for a while, and scolded bad weather.

At the beginning of spring, both dwarves could not hide their joy. Every day the amount of heat received by the ice from the sun was increasing, as well as its temperature, which the Degree-Teller carefully measured. The dwarves were very busy. But one evening the Heat-Teller didn't recognize his friend. The pale and confused Degree-Teller complained that for the second day the temperature of the ice was not increasing, but remained equal to zero.

"Look at the ice," said Degree-Teller excitedly, "It looks completely different. Water has appeared in many places, the roof of the hut is leaking. The temperature is not rising and the ice is changing its shape gradually. Soon it will change from a solid to liquid and will have no shape or volume at all, it will become liquid. It is terrible, I think the ice has got sick; at zero degree, it just melts. Do you, heat lover, know why the ice used to be healthy even in the sun?"

"All I know," his friend replied, "is that the Sun wants to melt the ice. But he failed to do it right away. In the beginning, the Sun had to send so much thermal energy so beloved by me to the roof of the hut that the ice could heat up to its melting point, or, as we used to say, thawing (for ice it is zero degree). Both yesterday and today he has managed to heat the ice to that temperature, but the ice is still there. Why do you think that happens?"

"Degree-Teller, are you saying that the Sun will need to release more thermal energy to melt the ice?"

"Of course, my friend, and without boasting, I am going to count it. But if tomorrow the Sun hides behind clouds and it gets colder, the Fox's hut will be temporarily saved. You are right, the Sun has done only half of his job, and without additional solar heat the ice will not melt. Yet, I really have no idea what to melt or to thaw means."

"I'm going to disclose this mystery anyway," the Degree-Teller declared. "Tomorrow, when the ice temperature on my thermometer reaches zero, I'll have nothing to do again. Then when it's light enough, I will try to get into the inner sanctum of ice, as well as any solid body, in its Crystal Lattice."

The Degree-Teller used to study at the dwarves' school once and heard that all solid bodies, like houses made of stones, were built of bricks-crystals, i.e., they had a crystalline structure. But the word *crystalline* was so long and difficult for him, and the word *lattice* brought back such terrible memories of his days once spent in the dungeon, that the dwarf decided to warn his friend, "Degree-Teller, be careful! You can be a wizard, but try not to stay behind that lattice forever."

The next day as soon as the temperature of the Fox's hut reached zero, the Degree-Teller pronounced three times the secret incantation heard from his grandmother and he was turned into a dwarf invisible even under a microscope. Charmed by the wave of sunlight, he lost consciousness for a few seconds and only woke up in one of the crystals inside his lattice. While his eyes were getting used to the darkness, he sang a song to banish his fear, "When the Sun melts the Fox's icy hut with the light, the clever dwarf will understand everything in this crystal lattice."

The Degree-Teller was about to repeat this verse, when suddenly he heard someone crying.

"Don't cry. I'm not going to hurt you. Let's get acquainted. I am the Degree-Teller," said the dwarf. Only then above his head, to his left and right, he clearly saw many balls arranged in a certain order and at the same distances from each other.

"My brothers and I are called Atoms," the boldest, closest ball introduced himself to the dwarf. - We, Oxygen and Hydrogen Atoms, are tiny particles that make up the ice crystal."

After looking closely at the Atoms and talking to them, the dwarf learned that the Balls-

Atoms are bound together by a great force, named **the Force of Interatomic Interaction**. It is what holds the Atoms together in this amazing order. "I'm going to sketch this Ice Crystal Lattice for the Degree-Teller," he thought. "My friend will be very surprised to see that image."

While the dwarf was drawing the balls in his notebook, trying to keep the distances between them equal, the Atom Brothers' cries intensified.

"What is wrong with you? Who has hurt you?" said the Degree-Teller to his good friend, the Oxygen Atom.

"Don't you feel it has become a lot warmer in the lattice?" the little man said in surprise. "We are crying because we feel the amount of internal energy of the whole crystal increasing. And the more heat the Sun sends, of which you sang so beautifully, the weaker the forces of inter-atomic interaction that bind us are, and the closer the end of our brotherhood is."

Suddenly the Oxygen Atom, startled by something, almost screamed:

"Degree-Teller, look! My Brother Atoms are moving away from me and I can't hold them back. How terrible, we're breaking up, our crystal has melted!"

"Wow, it's really hot," the dwarf remarked belatedly and habitually looked at the scale of his thermometer. "And my thermometer still reads zero! I wish the Degree-Teller were here to tell me exactly how much more heat the Sun has brought in since I *dived* into the lattice," the tireless researcher reasoned. "Oh, where is it? Where are the Crystal Atoms?"

Alas, the Atoms that surrounded him and made up the strict lattice of the Crystal were no longer there. And only after looking through binoculars, which always helped him out if necessary, the Dwarf found his new friends-Atoms moving at rather large distances from each other without any order.

Remembering the words of one of them about the forces of interconnection between the Atoms-Brothers in the lattice, the Degree-Teller exclaimed, "So this is what happens when these forces of interconnection between atoms are weakened by the action of solar heat: another substance, water, is formed from a solid crystal of ice!" In a few seconds he was already telling everything to his friend, the Heat-Teller [34, pp. 76-84].

4.3. Illustration of the third option

In designing the methodological development of a fairy tale, the fairytale-based lesson *The main secret of "Turnip"*, the first two principles of action and the principle of strict subordination of the plot fiction to the strategy of proactive formation of second-graders' knowledge of Mathematics basics are chosen as key ones. In this example, the folk fairy tale *Turnip* itself becomes didactic through problem tasks and questions to pupils based on its motives. *Turnip* has a great potential for pupils for learning the essence of *consistency.* It is revealed by Grandpa Didactic, who actually conducts a lesson of developmental character on a holistic platform of this folk tale potential.

"The search for the secrets of the folk tale the *Giant Turnip*", Didactic persuaded, "is the most worthy work for inquiring minds. Just don't forget that the weak-willed and alone cannot cope with *the Turnip.* It is not without reason that the tale itself underlines: *"A turnip cannot be dealt with by the weak. The granddaughter, the dog and the cat give Grandpa and Grandma their helping hands and paws, but some more help is needed!"*

And now, attentive girls and boys, tell me how many characters there are in *The Turnip.* Do they constitute a set?

Let us call this large set *Fairy Tale Characters.* We could have assigned a special number (from one to six) to each character, but we have not yet figured out the secret by which these characters are lined up one after another in the vegetable garden.

Now, please remind me, who's grabbing whom? The answer is as follows: *"Grandpa is grabbing the turnip, Grandma is grabbing Grandpa, the granddaughter is grabbing Grandma, the dog is grabbing the granddaughter, the cat is grabbing the dog, the mouse is grabbing the cat".*

Task 1. I wonder why Grandma grabbed Grandpa and not the mouse? Ah, the mouse wasn't there when Grandma came running to the garden. *Well done! You've figured out the secret, or as they say, the law, by which we will now assign numbers to all of our six characters. Grandpa who is the first to pick out the turnip becomes number one, Grandma is the second and she becomes number two. And will you assign the numbers to the rest of the characters?*

So, the cat receives number five and the mouse – number six as it is the very last to come. We do everything according to the law specified in the tale: the law takes into account the order the characters (members of the set) arrive at the vegetable garden. And it is considered that if the law by which a number is assigned to a particular member of the set, the sequence is specified. We have a given sequence of the characters of the fairy tale appearing in the vegetable garden: Grandpa, Grandma, the granddaughter, the dog, the cat, and the mouse. We can say that they come to the vegetable garden in the following sequence: 1, 2, 3, 4, 5, 6. Do you remember who is number four? And number five?

Numerical sequences, or just sequences of numbers, can be different. This usually happens when the law by which certain numbers and members of a set are *friends* with each other changes. But it also happens that the law has not changed, and the sequence takes a different form. So, at the end of the tale it is said, *"The cat is calling the mouse. The mouse is grabbing the cat, the cat is grabbing the dog, the dog is grabbing the granddaughter, the granddaughter is grabbing Grandma, Grandma is grabbing Grandpa, Grandpa is grabbing the turnip and they are all pulling and pulling and finally out is the turnip."*

Good for them! But it turns out that the sequence of the characters' arrival at the vegetable garden is the opposite at the end of the tale. Who comes to the vegetable garden last (the mouse) is the first in the final phase and vice versa (Grandpa is the last).

Task 2. *Try to write down a new number sequence so that it corresponds to the last indicated phrase of the tale. Remember that the law remains the same, and don't forget what numbers we have assigned to the characters in the tale.*

Indeed, at the end of the tale, this very numerical sequence is classified: 6, 5, 4, 3, 2, 1.

Task 3. *You have done a good job. Still, I wish you could find another sequence in the tale. And you will definitely cope with the new task! But first, list all the people pulling the turnip in the tale.*

They are Grandpa, Grandma and the granddaughter who are part of the set *People*.

Now, tell me which characters in *The Turnip* belong to the set of: a) pets; b) rodents?

How many members are there in each of the three sets – *People*, *Pets*, *Rodents*? There are three people, two pets, and one rodent in the tale. The mouse makes a singular set.

Is the number of the members in these sets the same? Is it increasing? No, on the contrary, it is decreasing: there were three members (Grandpa, Grandma, and the granddaughter), and now there are two (the dog and the cat); there were two, and now there is only one member left – the mouse.

How much fewer members are there in the set *Pets* compared to the set *People*? How much fewer members are there in the third set (rodents) compared to the second set *Pets*?

Starting from the second set, the sets are reduced by one. Here we have disclosed a new law, according to which another sequence is set in the fairy tale – the sequence of three sets. Each of the numbers – 3, 2, 1 – corresponds to the number of members from the sets *People* (3), *Pets* (2), *Rodents* (1), but so that, starting from the second set, each set contains fewer by one members than in the previous one.

The new sequence has only three numbers – 3, 2, 1.

It turns out that a sequence can be made up of sets, numbers, shapes, etc. The main thing is to discover the law of its creation [34, pp. 168–174].

The most striking examples of holistic and innovative didactic fairy tales of mathematical and physical orientation created by the author of the article without relying on well-known fairy

tales are *On the Beauty Parade of the Queen of Symmetry* and *Who is the Mother of the Ball Lightning?* [35]. Each of these tales is rather long, and therefore they are not reproduced here.

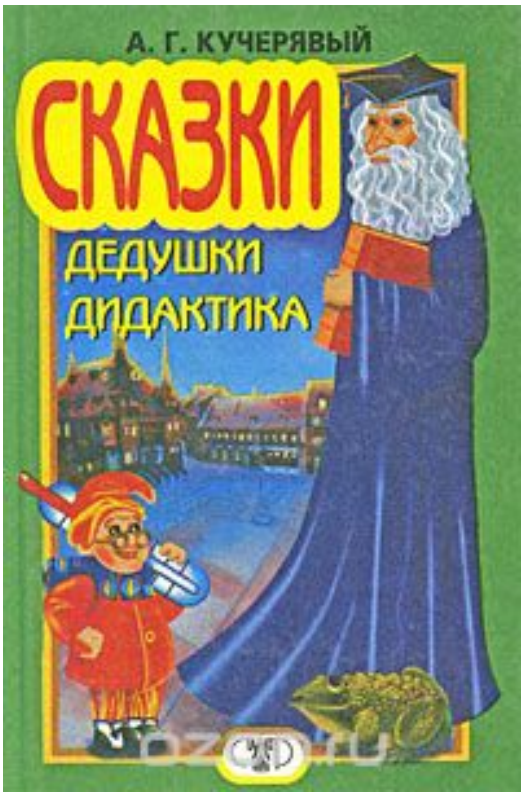

Figure 1. *Grandpa Didactic's Tales* [34].

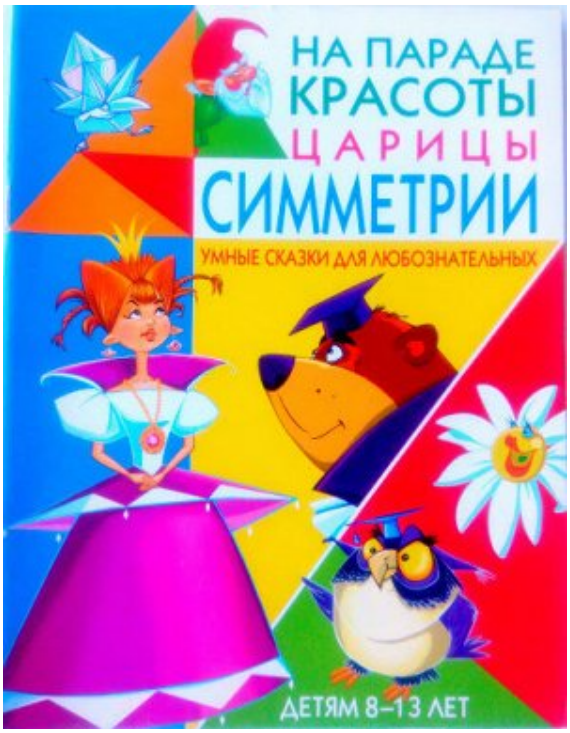

Figure 2. *On the Beauty Parade of the Queen of Symmetry: Clever Tales for the Inquisitive* [35].

5. Basic methods and techniques of creating holistic-innovative didactic fairy tales

The totality of relevant methods and techniques answers the main question – how to create a new didactic work in the form of a fairy tale? First, the choice of tactics of this process depends on the selected physical or mathematical content of the future didactic tale in accordance with goals of proactive training of these subjects and pupils' age (the third principle of the fairy tale design). Secondly, the designer should not forget to make his/her development (goals, the content, tools and methods of its design) personality-oriented (the fourth principle) including its subordination to the strategy of proactive Physics and Mathematics training (the fifth principle).

Hence, the method of integrity of the strategy and tactics of the didactic fairy tale design is the leading one. The strategy consists in turning it into a tool of developing pupils' cognition, their acmeological development as a personality, and tactics when choosing the scientific content, methods and fairy tale tools adequate to this strategy.

The best case scenario is when a primary school teacher is a fairy tale designer. At the stage of selecting scientific knowledge, he/she needs to create a didactic fairy tale. Here the following technique is of primary importance: to identify him/herself either with a mathematician or a physicist, and then – with a storyteller. The teacher should possess relevant knowledge and skills to match the main idea of synthesizing scientific knowledge and fairy tale tools of its literary representation.

Reflection as comprehension and reconsideration of experience stereotypes is essential in the system of the main methods of designing a fairy tale as a creative task. Reflexive extraction

and formulation of the problem, reflexive formation of the idea of its solution are among the most efficient techniques of this method. Reflecting from the viewpoint of a child is a special type of meditation. The teacher-designer simply needs to put him/herself in the place of a little discoverer, imagine how to emotionally perceive and analyze the problem situation suggested by the teacher, anticipate the course of their logical thinking when solving it. When planning creative tasks in mathematical and physical fairy tales, the teacher puts forward hypotheses for pupils and mentally designs probable options of their verification for each of them.

To make a didactic fairy tale appealing to children when telling them about complex things in a way that is accessible to them and simple, the teacher's method of identification with a pupil of a particular age also plays the key role in this process. Here the following techniques can be helpful: reproduction of images of the teacher's own childhood, reminiscences of his/her first steps in mastering a certain training material; comparison of images "He/she is a child of a particular age" and "I am a child"; transformation of the image "I am a child" into the image "He/she is a child of a particular age" on the basis of the author's temporary abandonment of certain features of the image "I am a child"; mental reproduction of the situation of acquaintance of a pupil of a particular age with the content of a fairy tale [34, p. 311–312].

It is clear that development of holistic and innovative fairy tale didactic works applicable to teaching Mathematics, Natural Sciences and special fairy tales lessons is certainly not limited to the above methods and techniques. Every teacher has his/her own creative tools and there are unique techniques of creating a literary and didactic product developed over time, conditioned by hereditary and axiological factors.

Some years ago, the Head of the Chief Department of Education and Science of Donetsk region started a pilot project of teaching the subject *Fairy Tale Lessons* (called Fairy Tale-Based Creative Lessons in some schools). The course targeted primary pupils and was based on the specific programme. In this experiment, the book *Grandpa Didactic's Tales* acted as a reference teaching guideline. The author's design of didactic fairy tales reflected in that and other books as a creative task for the first grade was carried out mainly according to the conceptual scheme disclosed in this article.

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