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Narratives in STEM Education

Narracje w edukacji STEM

KEYWORDS

narratives; STEM education; interest; involvement, preschool

ABSTRACT

Looking from the perspective of the requirements of the modern world, STEM education is a significant challenge related to teaching both people whose professional paths will be associated with STEM and those who will use knowledge in this area "unprofessionally" – only to solve everyday problems. Teachers and educators face a difficult challenge related to arousing the interest of learners in the subject of STEM, developing understanding of scientific concepts and processes, and strengthening the involvement in scientific activity. Narratives are becoming an important tool available to educators in the implementation of this task. They can arouse the students' interest through an attractive form of presentation of, e.g. the figures of outstanding scientists or brilliant discoveries. Such forms of presentation can introduce both basic and advanced scientific knowledge, and, at the same time, save cognitive resources, strengthening the children's involvement by making them actively participate in discovering not only the scientific laws, but also the meaning (including the personal one) of science. It is also important that narratives can become a useful tool for building the positive image of science as a world accessible to everyone, regardless of gender, age or origins.

The purpose of this article is to indicate only a few areas of possible applications of narratives in STEM education, and to encourage the use of various narrative materials in education in this area at various stages of education.

SŁOWA KLUCZOWE

narracje, edukacja STEM, zainteresowanie, zaangażowanie, przedszkole

ABSTRAKT

Edukacja STEM, patrząc z perspektywy wymagań współczesnego świata, stanowi istotne wyzwanie, związane z uczeniem zarówno osób, których ścieżki zawodowe związane będą ze STEM-em, jak i tych, które będą korzystały z wiedzy w tym obszarze „nieprofesjonalnie", wyłącznie do rozwiązywania problemów życia codziennego. Nauczyciele i wychowawcy stają przed trudnym zadaniem związanym z wzbudzeniem zainteresowania uczących się systemem STEM, rozwijaniem rozumienia pojęć i procesów naukowych oraz wzmacnianiem zaangażowania w aktywność naukową. Istotnym narzędziem dostępnym dla edukatorów w realizacji tego zadania stają się narracje: wzbudzające poprzez atrakcyjną formę przekazu zainteresowanie, np. postaciami wybitnych naukowców czy genialnych odkryć; wprowadzające w sposób oszczędzający zasoby poznawcze zarówno w obszar podstawowej, jak i zaawansowanej wiedzy naukowej; wzmacniające zaangażowanie poprzez zaproszenie dziecka do aktywnego uczestniczenia w odkrywaniu nie tylko praw, ale i znaczenia, w tym także osobistego, nauki. Co również istotne, narracje mogą stać się użytecznym narzędziem budującym pozytywny obraz nauki jako świata dostępnego dla wszystkich, bez względu na płeć, wiek czy środowisko pochodzenia.

Celem artykułu jest wskazanie jedynie kilku obszarów możliwych zastosowań narracji w edukacji STEM oraz zachęta do korzystania z różnorodnych materiałów narracyjnych w edukacji w tym obszarze, na różnych etapach kształcenia.

Introduction

The indication of the two ways of thinking – paradigmatic and narrative one (Bruner 1986) activated a series of various consequences in psychology and other social sciences. What is the difference between those two ways of thinking? According to Emilia Soroko, the paradigmatic one:

> (…) refers to understanding the world through generalisations and detection of connections among events, obtained through logical justifications and searching mainly for the physical causality. And due to the narrative way of thinking, understanding the social world, and oneself in this world, is obtained through building stories about people and their lives through connecting, arranging and explaining the behaviours, taking into account the principles of the inner world (intentions, needs, feelings, convictions). (Soroko 2013: 6)

In order to better understand the difference between those two ways of thinking, we can simplify this thought to connecting the paradigmatic way with the "hard," objective perception of the reality and the narrative way with the "soft," subjective perception. Following this division, we can assume that paradigmatic thinking plays a more important role in processing scientific data, and narrative thinking is necessary for processing the individual's experience. This assumption "reserves" language connected with the paradigmatic way of thinking for science, which results in the reluctance to use language connected with narratives in science. Thus, the researchers who are against connecting science with narratives, shall definitely declare: "The plural of anecdote is not data" (Dahlstrom 2014).

According to Michael F. Dahlstrom (2014: 13614-13615), the difference between the scientific and narrative message is characterized by three aspects. The scientific message presents the laws that are possible to be applied in different situations, vulnerable to generalization, and providing real chances to predict some phenomena. On the other hand, the narrative message gives an example of a specific case, on the basis of which one can create hypotheses related to the general laws enabling the occurrence of such a case. Thus, this difference boils down to the deductive versus inductive nature of the paradigmatic and narrative thinking. The second difference is related to connecting the content of the message with the context – while the language of science is free from the context, a narrative is strongly dependent on the context (scientific facts presented in any place and time shall sound the same, but narratives – not necessarily). Finally, the determinant of the "truth" of the scientific message and the narrative is based on different criteria. Scientific truth is based on accuracy, while a narrative is based on verisimilitude.

Now we could stop the considerations and let science and narratives flow in two separate riverbeds, but they do have a few aspects in common, as a result of which they have a real chance to meet. While comparing the two ways of thinking – the narrative and paradigmatic one, we can notice the superiority of the former in several aspects: first – in arousing motivation, interest and involvement; second – in using the resources while processing information; third – in elaborating knowledge; and finally – in transferring the obtained information to the long-term memory. Such superiority of the narrative message results from *dramatization*, *emotionalization*, *personalization* and *fictionalization* (Glaser 2009, after: Dahlstrom 2014: 13615). Thus, the narrative way of processing information seems inadequate in case of c r e a t i n g the basics of knowledge, but it may be very useful in t r a n s f e r r i n g such knowledge in the process of education.

Narratives and identity

STEM education aims at introducing – into the world of science – those who shall not use the obtained knowledge in a professional manner in future, and those whose careers shall be connected with STEM. In case of the first group, it seems important to make young people familiar with scientific thinking and help them find connections between science and the experiences of everyday life. And from the perspective of the requirements of the modern world, in which we need a lot of people performing jobs related to STEM, it is important to reach the second group of learners – young people who may consider choosing STEM-related careers in the future.

The question that appears at this point may be formulated in the following manner: why do children who, in the kindergarten, are fond of watching and making scientific experiments, full of interest, willing to formulate and verify hypotheses, and enthusiastic about the scientific understanding of the world, grow up to become adolescents totally rebellious against everything that is connected with "exact sciences"?

The answer to this question (or at least one of the possible answers) can be given with reference to the narrative nature of the identity built in the adolescence. In the process of recognising and negotiating the opportunities that are available to the individual and adjusted to his/her possibilities, the elements that do not match the person's story about oneself are removed, and the elements that respond to the individual's important needs appear. Young people's life choices are not final decisions made at a certain moment of life – rather, it is a gradual, constant process of negotiation, which takes into account the requirements of the external world, culture and society – the process of creating new meanings, new choices and new identities (Holmegaard, Ulriksen, Madsen 2015).

A young person who functions in a social-cultural space, is immersed in the stories about scientists. Such stories present the image of the man dealing with science, who does not have to match the (desired) image of "I". A person who deals with science "has brains" which, in case of many teenagers, does not match their view of themselves (it is good to participate in scientific activities, but I am not a scientist because science is for those who are better than me). Another stereotypical image of a scientist is that of a "freak" – a person who is less attractive, popular, socially competent and creative. Also, exact sciences themselves are perceived as difficult, non-creative and non-social ones (Regan, DeWitt 2015).

Therefore, negative narratives may obliterate the trace left by the positive experiences with STEM education in childhood. On the other hand, we should not reject the meaningfulness of carrying out such actions due to the fact that childhood memories can be the basis for shaping one's identity in adolescence, which is proved by the motif: "When I was a child…" in one's story about oneself.

Thus, we can see that "negative" narratives can block the individual's developmental potential in the field of science, but, at the same time, we have to notice that "positive" narratives can be a weapon – both in arousing interest, developing the understanding of concepts and scientific processes, and in encouraging a person to participate in scientific processes.

Stories about the world of science

One of the most popular ways to use narratives in STEM education is telling young people about outstanding scientists or brilliant discoveries. Even a superficial analysis of the books available on the market show that there are many books about extraordinary people, dedicated to children – e.g. the books related to Maria Skłodowska-Curie. On the Polish market we can find such books in different formats: traditional books, audio-books or books available in a digital form. They are dedicated to readers at various ages: young children, early school children, elder school children and adolescents; and they are focused on the biography and/or scientific ideas of a given scientist.[1]

The narrative nature of the books about extraordinary scientists results in the fact that a story often includes linguistic features, typical of a narrative, that place the plot in time and space, indicating the characters, introducing complications and giving references to the characters' internal states, e.g. "One day, a Russian soldier came to visit us. The whole class quickly switched into Russian. Everyone was nervous."

If, adapting the definition of a narrative suggested by Nancy L. Stein (1997), we assume that the central point of a narrative is the character's establishment of the objective, we can see that this category is very important in the narratives concerning extraordinary people. This is how the editors encourage the readers to read the book: *Mania – dziewczyna inna niż wszystkie* [Mary – the Girl Different than Other Girls]: "It is a fascinating story about the Polish Nobel Prize winner who had to overcome many obstacles to achieve her objectives" (https://zuzutoys.pl).

A good narrative is – like in the above example – "fascinating," or "thrilling," like in the editor's description of the series of books: "Wielcy i sławni" [The Great and the Famous] ("the books are to show thrilling stories about the history of outstanding scientists" [https://www.proszynski.pl]). Drawing the readers' attention seems crucial

[1] The examples of such books include: Sobieszczak-Marciniak M. (2017). *Maria Skłodowska-Curie*, Warszawa: Wydawnictwo RM; Vera L., Cugowa L. (2008). *Nazywam się... Maria Skłodowska-Curie*, Poznań: Media Rodzina; Czerwińska-Rydel A. (2017). *W poszukiwaniu światła: opowieść o Marii Skłodowskiej-Curie*, Łódź: Literatura; Graham I. (2008). *Maria Skłodowska-Curie i promieniotwórczość*, Warszawa: Wydawnictwo Arkady; Grodek J. (2017). *Mania – dziewczyna inna niż wszystkie. Opowieść o Marii Skłodowskiej Curie*, Warszawa: Wydawnictwo Zuzu Toys.

to the authors and book distributors, so no wonder that they present "the profile of Maria Skłodowska-Curie by transferring serious knowledge in a funny manner" (https://www.empik.com). Thus, it is not surprising that anecdotes are used in the books, e.g.: "Einstein was famous for being absent-minded enough to wear two different socks on his feet" (Grodek, Fus 2017: 41).

Such stories arouse the reader's interest in scientists and inventors, but they do not guarantee that the recipients shall actually increase their engagement in scientific activity – such engagement which makes the learner:

> (…) select tasks at the border of their competencies, initiate action when given the opportunity, and exert intense effort and concentration in the implementation of learning tasks; they show generally positive emotions during ongoing action, including enthusiasm, optimism, curiosity, and interest. (Skinner, Belmont 1993: 572)

It is worth emphasizing that reading a biography of a great mind does not have to facilitate decreasing the distance between the child and science (on the contrary – it can even increase such distance); such a possibility only results from direct actions.

Narrative education in the virtual world

In the 1980s, *The Fifth Dimension* project was created (Hakkarainen 2004). The objectives of its authors were as follows: first – designing activities that shall be interesting for the children; second – creating the space that makes it possible to communicate (both in the written and oral form) in the context of problem-solving; third – providing the children with different activities; fourth – attracting both boys and girls to the world of new technologies; and fifth – elimination of thinking about playing games and staying in the virtual world as a reward/bribe for a child for doing what the adult wants (Hakkarainen 2004: 5).

In the world of the Fifth Dimension, the child is to travel in a virtual labyrinth with the Game Master in the form of a Wizard. The child is encouraged to take up various activities connected into one whole with the elements that bind the narrative. The contents (connected with, i.e. STEM subjects), appear in the form of tasks that require solving specific problems. According to its creators, the narrative layer of the game gives the child the sense of authorship – it encourages the child to formulate their own objectives, work out their own problem-solving strategies, make decisions, and confront the consequences of those decisions.

Within the last thirty years, there have been many ideas to use the virtual world as the narrative environment for teaching STEM contents. An example of such an idea is "Crystal Island: Uncharted Discovery" (Lester, Spires, Nietfeld, Minogue, Mott,

Lobene 2014). In this project, the scientists used the solutions applied in adventure games (with a rich plot, a set of characters, solving riddles) and action games (with time pressure, developed characters, collecting things). The story presented in the game starts from a ship being wrecked on an island. A group of castaways are trying to send the SOS signal to the world. Under the adventure layer there is an educational layer related to teaching understanding and using maps and models. Using the complicated mission, the player, almost unconsciously, develops his/her abilities to solve problems, read maps and navigation devices.

While justifying the rightness of this way of learning, the above-mentioned Pentti Hakkarainen pays attention to the difference in experiencing the confrontation with a problem by an adult and by a child. When an adult faces a (scientific) problem, he/she sees it from a distance, as it really is. The child, due to the power of his/her imagination and emotional identification, is "inside the problem" (Hakkarainen 2004: 11). According to Hakkarainen, the suggestion for "narrative learning" seems particularly attractive with reference to the education of children at the preschool and early school age. It is because, in this suggestion, learning takes place on the verge of what is real and imaginary; learning is immersed in playing and activity facilitates giving meaningfulness to the process of studying.

Tasks with a text and a text with tasks

A sceptical voice could say that using a narrative in education, e.g. a mathematical one, is nothing new. Surrounding the scientific message with the layer of a narrative has been used in education for many years. Apart from such tasks as: "Count the division 58500:80," in mathematics handbooks we can also find tasks in which a narrative is used. Here are several examples from the handbook *Matematyka z Plusem* for fifth-graders (Dobrowolska, Jucewicz, Karpiński, Zarzycki 2019), in which the authors presented some mathematical problems with the use of a narrative: the characters of the story have an internal life ("The Inhabitants of Fraction Town love fractions and mixed numbers..." [p. 67]); there is a plot: "A caravan of 17 camels went into the desert. Each camel carried 16 skins of water. The travellers used water from 9 skins every day. After 12 days they arrived at an oasis. How many skins of water did they have left?" (p. 42); there are some dramatic elements: "A number is lost! Here is the description of the number: it includes four digits, it is larger than 9500 and smaller than 9600; it is dividable by 9 and it is dividable by 10. There is a reward for the one who finds it. The Number Office" (p. 53). As we can suspect, through the narratives the authors wanted to make the students more interested and involved in the process of finding the solutions.

This way of using the narrative in mathematical education is known in our education, but there is also an alternative manner, suggested by Elisabeth McClure and her colleagues (2017). The authors do not start from a task, which is covered with a narrative, but from the narrative itself in which we can find the pretext for STEM education. As an example, they give the situation of reading, together with the child, a book in which the young person is to find the hidden character. A simple activity is transformed into the opportunity to form hypotheses, test them, and experience their falsification and verification. The authors find such activity valuable for at least two reasons. First, it makes it possible to show the children that what they do is a scientific activity, which may facilitate the child's identification with a scientist. Thus, the STEM educator's role is not only to make the child interested and involved in the task, but also (or most of all) to make him/her aware of the omnipresence of science and the meaning of his/her activity. Second, such activity can equip the child with an important tool for dealing with failures. The failure to find the hidden character – another falsification of a hypothesis, teaches the child to believe that a failure is something that is necessary and developing in a narrative.

Conclusion

It is true that anecdotes shall not replace facts, and the universal language of science shall not be replaced with narratives, but the paths of stories and science often cross. As Yannis Hadzigeorgiou and Roland M. Schulz (2019) have noticed, perceiving science as a set of laws and rules written in their final version in handbooks is limiting. Before a ready "scientific product" was made, an outstanding mind carried out an analysis which was later translated into the language of symbols, coded and objectivised. Scientific knowledge is not given as a ready product; it is built and a story is often hidden at its base (Hadzigeorgiou, Schulz 2019: 3) – like in the one about Archimedes' bath or Newton's apple.

However, if we analyse the assumptions of STEM education, we shall see that narrative and education meet (or at least may meet) not only by the sources, but also here and now. Each of the key characteristics of STEM education may profit from narrative as the latter indicates the binding elements among particular disciplines of that acronym, increases the learners' involvement in the active participation in the process of learning, and significantly connects the curriculum contents with the real needs of the students.

If we assume that one of the objectives of STEM education is also reinforcing the sense of social responsibility, we can notice the important role of narration in the area of making the students sensitive to ethical dilemmas related to science. The awareness

of the fact that an invention may improve people's lives or – on the contrary – hurt many people, is the consequence of activating the narrative way of thinking. At this point, it is worth emphasizing the didactic potential of the virtual learning environment, which makes it possible to simulate events that are impossible to be staged in the real world.

However, the most important mission to be played by narration in the world of science, is the one related to promoting the idea of "science for everyone" – irrespective of gender, the environment from which the learner comes, regardless of his (or her) age. In the above, very limited, reflection on the education I focused on children and adolescents, however, one cannot forget that the postmodern world requires lifelong learning. The specificity of adult cognitive functioning – the development of relativistic and dialectical thinking, the ability to discover problems (Gurba 2011) promotes the use of narrative tools in STEM education. In a dynamically changing, inconsistent, demanding reality, wisely used narrative – both as a metaphor and a carrier of concepts, offers educators a number of interesting possibilities.

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