

Humanitas Pedagogy and Psychology, pp. 87-100

ISSN: 2956-3992

Statement on research results

Received on: 4.07.2022

Review date: 17.10.2022

Publication date: 31.12.2022

Sources of publication financing: Academy of Special Education them. M. Grzegorzewska in Warsaw, *Dziecięca geologia. Modele umysłowe starszych przedszkolaków i młodszych uczniów w zakresie budowy wewnętrznej Ziemi i zjawisk w niej zachodzących*, BSTP 5/19-I. *Dziecięca geologia. Modele umysłowe starszych przedszkolaków i młodszych uczniów w zakresie budowy wewnętrznej Ziemi i zjawisk w niej zachodzących*, BSTP 5/19-I.

DOI: 10.5604/01.3001.0016.3197

Author's Contributions:

(A) Study Design

(B) Data Collection

(C) Statistical Analysis

(D) Data Interpretation

(E) Manuscript Preparation

(F) Literature Search

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CHILDREN'S GEOLOGY. 6, 7 AND 8 YEAR-OLD CHILDREN'S UNDERSTANDING OF THE PHENOMENA OF VOLCANIC EXPLOSION, MOUNTAINS FORMATION AND ACCUMULATION OF SNOW ON MOUNTAIN PEAKS INTRODUCTION

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Many researchers emphasize that teachers should monitor children's beliefs, especially those that deviate from scientific explanations (Francek, 2013; Vosniadou and Brewer, 1992). Existing naive beliefs can hinder the acquisition of scientific knowledge (Özsoy, 2012). This is particularly important in the formation of basic concepts about the world. In the area of the inanimate nature, the key concepts are related to the construction of a landscape (Korzeniewski, 1985).

In Poland, there are few studies that aim at establishing children's reasoning in the context of inanimate nature (Wiśniewska-Kin, 2007; Klus-Stańska, 2004). On the other hand, on the basis of the conducted research (Al-Khamisy, 1996; Guz, 1993), it was impossible to determine how children moved from explanations based on personal experience to explanations close to science. Moreover, many of the studies were conducted decades ago (Wilgocka-Okon, 1967; Lelonek, 1984; Korzeniewski, 1985). Their results may be devalued due to advances in science and children's better access to the scientific knowledge (Cardoso et al., 2018). Secondly, the direct transposition of foreign research results, without their prior verification, may not be justified due to cultural differences (Saçkes et al., 2016; Jelinek, 2020). The Comparative studies are necessary, but they require diagnostic research to determine how Polish children explain the phenomena of the surrounding world.

This article presents research results revealing the understanding of the following phenomena provided by 6, 7 and 8-year-old children: volcanic eruption, mountains formation and the accumulation of snow on mountain tops. These phenomena occur in the Earth's lithosphere. The phenomenon of a volcanic eruption is associated with the penetration of magma to the Earth's surface. The formation of mountains occurs due to the movement of the Earth's tectonic plates. The third phenomenon described in the article is the accumulation of snow on the mountain tops. It is related to the persistence of low temperatures at these altitudes.

Since these phenomena occur over a long period of time and they are rarely observed, it has been assumed that indirect sources are of great importance in the process of creating concepts (Jelinek, 2021). The difficulty in accepting a scientific explanation is connected with the fact that the information acquired by children does not fit to the internal structure of children's knowledge, which in the first stages of children's development is supplemented by everyday experiences (Francek, 2013).

The conceptual development begins with constructing explanations based on personal experience. It is also connected with gradual incorporation of information provided by adults (Vosniadou & Brewer, 1992). It is assumed that the process of constructing concepts about the internal structure of the Earth occurs in a similar way (Cardoso et al., 2018; Blake, 2005). Unfortunately, due to the abstract nature of the discussed phenomena, the important is the fact that school education

does not provide the opportunity to learn about the phenomenon of the internal structure of the Earth (Jelinek, 2021). The information obtained from the media remains a key source of knowledge. However, it should be remembered that information delivered by the media is also the main cause of many misconceptions in children (Barnett et al., 2006).

Determining how children explain these phenomena is intended to help teachers cognize children's understanding of phenomena and provide basic knowledge necessary to organize educational situations in which teachers can support children in constructing their basic geographical concepts.

METHODOLOGY

The intentionally selected group of 50 children from a medium-sized town in the suburbs of Warsaw was researched. The researched children were the 6 to 8 year-olds (average 6.8). The group consisted of 25 older preschoolers and 25 first-grade school children. Among the respondents there were 17 boys (including 12 boys from kindergarten and 5 boys from school) and 33 girls (including 13 girls from kindergarten and 20 girls from school).

Uncategorized interview was applied during the study. During the conversation, children were shown a fold-out brochure with schematically drawn illustrations. They were asked questions. The article analyzes three of them: (1) *There is a volcano in the picture. Tell me what a volcano is? Where do you think the volcanoes magma and lava come from?* (2) *How are mountains formed?* (3) *Why are the tops of the mountains white but they are not white at their bottom?*

In the case when a child's answer was not understandable, the researcher was asking further questions in order to understand a child's belief better. The children's utterances were recorded and then shorthanded and analyzed. Children's statements were classified in terms of similarity (Vodniadou & Brewer, 1992). At the first (out of two) level of generalization, statements, in which children used the same words (key words), were collected. At the second level, phrases with the same meaning (context) were gathered. By means of gradual generalization, several beliefs were formulated in each of the discussed issues. Children's ideas were arranged in sets: from those based on personal experience (initial), through those in which adult explanations were revealed (simplified), to those providing concepts close to science.

RESEARCH RESULTS ANALYSIS

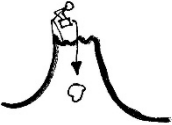


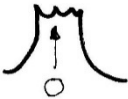
At the very beginning, I would like to point out that 21 children answered: *I don't know* for each of three questions. Their answers, although numerous, were not taken into account in the answers classification. However, crucial was the fact that the children answering the questions were not the same all the time. Some of them gave up formulating an answer to the question about the formation of volcanoes. They were active in answering the question, for example, about the cause of snow lying on the tops of the mountains. This may have been due to the fact that these children were completely unable to determine a meaningful answer to some questions. In other areas they felt that they had the right information.

While presenting an illustration of a volcano, children were asked what a volcano was. According to the scientific explanation, volcanoes are permanent places where lava, pyroclastic materials and gases come out from the depths of the Earth. A volcano is called a volcanic cone, inside which, at the bottom of the chimney, there is an igneous focus. Through the crater, the liquid rock (lava) flows to the surface, where it solidifies to form volcanic rocks (Pietkiewicz and Źmuda, 1973).

All the examined children explained that volcanoes were erupting and that it was hot inside. They had difficulty explaining what the liquid form of the rock was. The children used the term suggested by the researcher: (lava, magma), but it was not certain whether these expressions concerned the mentioned hot liquid. Magma was often described as *a fire* and *very hot water*. The latter term seemed to be close to the observation of boiling water, as proven by the descriptions: *Hot water turns orange* and *Bubbles appear in hot water; Water with some coal inside, it turns into lava*. Some children describing the behavior of the volcano added that the Earth was shaking during the eruption.

Children's answers to the questions: *Where does volcanic lava come from?* and *How does it happen that volcanoes erupt?* were related to the idea of the internal structure of the Earth. Omitting the answers such as: *I don't know* (21 children), children's beliefs in five categories sorted from those dominated by personal experience to those close to science are presented in the Table 1.

Table 1. Children's beliefs about the origin of lava inside volcanoes

Beliefs	Children's explanations	Number of children
Preliminary: <i>people pour magma into a volcano</i> 	Children were explaining the origin of magma and a volcano eruption as the human activity: pouring magma into the center of a volcano (<i>people pour fire there</i>), and digging the ground, which according children, caused a volcano to erupt (<i>people dig and a volcano erupts</i>).	2
Preliminary: <i>the sun heats the stones and they explode</i> 	While constructing an explanation, children looked for the cause of a volcanic eruption. They associated this process with high temperatures inside a volcano. Searching for the source of this heat, they combined it with the well-known process of heating caused by the sun's rays. Children explained that the volcanic magma was erupting because it was heated by the sun. <i>The sun was so hot and then these stones got very hot and they grinded and grinded until the lava came out.</i>	6
Simplified: <i>magma comes from the center of the Earth</i> 	Children pointed out that magma came from the center of the Earth (they talked about <i>the core of the Earth</i>). They imagined that a volcanic vent was a canal connecting the center of the Earth to its surface. Magma flowing through it came from the center of the Earth. Seven-year-old Gabryisia explained that <i>when the Earth was formed and the plates collided, a volcano was created</i> . She believed that volcanoes were formed as a result of tectonic plates overlapping each other. She also believed that volcanoes were connected to each other by means of the Earth's core.	9
Simplified: <i>magma is located underground</i> 	Children searched for an explanation of the location of lava inside the volcanic cone. They explained that magma was located deeply in the Earth, but they could not pinpoint where exactly. They used the term <i>underground, from the bottom</i> . They believed that magma came from the interior of the Earth and flowed in an unspecified way to the outside of a volcano. They explained that when there was too much magma, the volcano was pouring it out.	12
Close to a scientific explanation: <i>magma comes from the Earth's mantle</i>	None of the children explained that magma came from the Earth's mantle.	0



Source: own study.

An explanation of the volcanic eruption process was provided by the 29 surveyed children. At the level of preconceptions, the children believed that lava and volcanic eruptions were the result of human labor. Others believed that the temperature of the liquid magma was due to the sun's rays. The simplified beliefs differed from preconceptions with reference to the source of magma. None of the children presented the explanation that magma came from the Earth's mantle. In turn, the explanations suggested by children indicated two locations. One location was in an unspecified place below the surface of the Earth (somewhere, deep). Others placed magma in the core of the Earth.

The impossibility of direct observation and the rudimentary knowledge of the internal structure of the Earth were the immediate causes of preliminary and simplified beliefs. It should be remembered that the schematic pictures of a volcanic eruption, available in publications for children, do not usually show the entire cross-section of the planet. They rather focus on the volcanic cone and igneous foci. The latter is rarely localized across the globe. Thus, children, who had managed to get to know this phenomenon, had difficulties in localizing them. It was not surprising, therefore, that the examined children were unable to explain the broader context.

Similarly, to the question about the cause of volcanic eruptions, 21 children admitted not knowing any answers to the question: *How are mountains formed?* Three children gave incomprehensible explanations. The statements of the remaining 26 children were divided into six types of beliefs, the detailed description of which is presented in Table 2.

Table 2. Children's beliefs concerning the formation of mountains

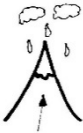
Beliefs	Children's explanations	Number of children
Preliminary: <i>stones join together</i> 	The children believed that <i>stones join together</i> and form a heap (<i>rocks merge in water, join and grow larger</i>). This explanation was probably related to the observation of an excavator piling up a mountain of stones.	3
Preliminary: <i>mountains are made by people</i> 	The mountains were built by a man (<i>because when digging a hole, a mountain is created next to it; people dig and heap</i>). The origin of the mountains is artificial. Probably children had obtained their knowledge from plays in a sandbox.	6

Preliminary: *a lot of snow falls on one place and a mountain is formed*



Snow falls from the sky until small and then larger mountains are formed (*from snow, it was snowing and such larger mountains were created*). Children, who referred to snowing, believed that mountains were made not of stones but of snow. 8

Preliminary: *the ground grows and the mountain rises*



A mountain is formed just like the growing grass. (*The grass is small at first, then the mountains grow*). All this happens during the rain (*watering*), then „a mountain made of soil” grows. Children probably associated the formation of a mountain with the growth of watered plants. 3

Simplified: *the ground rises and a mountain is created*



Children explained that mountains were formed by the rising of the ground. (*The ground rises and mountains are created*). These children did not refer to the falling rain (an apparent cause). They rather pointed to an underground source, but could not specify it. 2

Close to a scientific explanation: *mountains are formed through the movement of tectonic plates*



Children used the term *plates* to refer to tectonic plates. They explained that the colliding plates caused the formation of a peak (*there were such plates and they collided and mountains grew*). One of the children, who was explaining what the plates were, said: “*they are like boards, made of stone and they touch each other and they grow upwards*”. 4




Source: own study.


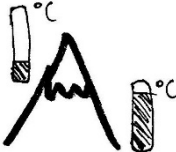
Preliminary beliefs, which based on personal experience, were related to playing with sand, stones and snow. Explaining the formation of mountains, children said that mountains were formed as a result of piling up sand, stones and snow. There were also beliefs relating to the growth of grass as a mountain. Simplified

beliefs included information provided by adults and from media reports referring to the rising of the ground. However, these children were unable to explain the reason why the ground was rising. At a level of beliefs close to a scientific explanation, four children used the term *a plate* and they used it analogously while explaining the movement of tectonic plates. Because this term is characteristic of a scientific explanation, it was classified as close to the scientific explanation.

When children were asked: *Why are the tops of mountains white but they are not white at their bottom*, 21 children stated that they did not know the explanation for this phenomenon. 5 children formulated an incomprehensible statement and the remaining 24 statements were grouped into 5 types of beliefs. They are summarized in Table 3.

Table 3. Children's beliefs about snow on mountain tops

Beliefs	Children's explanations	Number of children
Preliminary: <i>there is snow on the tops of mountains to make them pretty</i> 	Children said that the snow only fell on the top of a mountain <i>to make it pretty</i> . In explanations, they did not pay attention to the natural causes of this phenomenon. Children considered this phenomenon only in terms of aesthetics. One of the kids said the snow on the top of a mountain was <i>glued</i> .	3
Preliminary: <i>snow only falls on the top of a mountain</i> 	Children believed that snow fell only on the top of mountains, not on the slopes (<i>snow is falling, and there is no reason for it; it only falls on the tops</i>). Therefore, the slopes of the mountains were not covered with snow. This explanation was volitional.	7
Preliminary: <i>the wind sweeps the snow to the top of a mountain</i> 	Children believed that <i>the wind blew the snow to the top of a mountain</i> , causing the snow to stay only on the peaks (<i>because sometimes the wind puts together the snow, sometimes there may be no wind at the top</i>).	4

<p>Simplified: <i>the sun illuminates a slope of a mountain, not the top</i></p> 	<p>Children believed that the sun strongly illuminated the mountainside, causing its slopes to warm up and the snow to melt. According to children, the mountain tops were not heated so much. One of the children compared the top of a mountain with winter, and the valley with summer, saying: <i>maybe when it is winter here, it is summer there, so we transform, just like now it is spring here in Poland, and it is winter in America.</i></p>	4
<p>Close to a scientific explanation: <i>it is colder at the top of a mountain</i></p> 	<p>The children pointed out that mountain tops were cooler than the valleys. They explained that it was colder at the top and thanks to this the snow stayed on the peaks and melted faster in the valleys. One of the children said: <i>it was warm down there, because the higher it was, the colder it became and there was less oxygen.</i> These children could not explain the colder temperatures on the mountain-tops, but they were sure of the explanation.</p>	6

Source: own study.

Children, who based their opinions on personal experience, considered the cause of the snow-covered mountain slope and the selective action of wind and snow (it blows/falls only on the top) in aesthetic and volitional terms (Piaget associates this type of explanation with egocentrism and animism). Simplified beliefs were related to the consideration of the low temperature index and the heating process. The reasons for the lack of snow on the slopes of the mountains were caused by the sun rays. Children decided that the sun rays melted the snow on the slopes. However, in this case, they seemed to interpret the phenomenon selectively (sun rays fall only on the slopes of the mountain, not on the top). Referring to the seasons of the year as an analogy proved that children, when constructing explanations, interpreted them through the prism of phenomena that they were familiar with. Winter – as a season of the year – was associated with snow. Connecting a snowy peak with winter, they claimed that it was winter there. On the other hand, children, who referred to the sun rays, believed that the phenomenon of snow disappearance from the mountain slopes had to be related to heat. This type of belief was considered as close to the scientific explanation because children were thinking about imperceptible phenomena – this was one of the indicators for building *higher* beliefs. On the other hand, children, who knew that on the tops of the mountains there appeared lower temperatures than in the valleys, explained the lack of snow on the slopes due to the difference in temperatures.

CONCLUSIONS AND DISCUSSION

The analysis of children's explanations made it possible to describe different beliefs in every of the researched areas and to sort them from those based on personal experience to those in which children used information provided by adults.

Among the three research areas, 21 children stated that they did not know what the cause of the phenomena was. Such a large number of answers proved that these questions were not included in the cognitive interests of the surveyed children or the created situation did not encourage them to reveal their own beliefs. Others, who were eager to present their explanations, seemed to come up with it on the spur of the moment. Jean Piaget (2006, pp. 20-36) calls such explanations as induced. He claims that these explanations reflect the mental processes in children and their knowledge. The research revealed artifactistic explanations in which children explained the phenomena by referring to deliberate human work (e.g. people pour lava into a volcano). The research results confirmed not only Piaget's findings (2006) but also Al-Khamiza's (1996), who obtained very similar answers among the 6-year-old children. There were also observed children-specific explanations in which they selectively interpreted the occurring phenomena. For example, when they were explaining the snow-capped mountain tops, they said that the sun's rays operated only on the slopes of the mountains, not on the peaks. Such explanations were related to children's dualism, which is explained as: accepting two contradictory explanations and ignoring this contradiction at the same time (Piaget, 2006, pp. 109-110).

Following Vosniadou and Brewer (1992), the research assumed that children's beliefs, which were sorted from pre-scientific to scientific, determined the developmental model of shaping concepts. On the basis of this assumption, the development stages of the formation of concepts related to a volcano eruption, a mountain formation and accumulation of snow on mountain peaks were described. In this context, the **preliminary beliefs**, which were the essence of everyday experience, were the first steps in constructing scientific beliefs. At this stage, children relied primarily on personal experiences and they did not take into account the information they had heard or seen in the media. Firstly the children interpreted the volcanic eruption by explaining the reasons of the existence of volcanic lava. Some claimed that it was intentionally poured into a volcanic cone and then it exploded. Perhaps this was related to the description of lava as hot water poured into, for example, a pot. It was similar to the explanation of the mountains formation phenomenon. The vast majority of respondents (22) interpreted this phenomenon referring to a mountain made of, for example, sand. It was not different from explanations of snow was accumulated in the upper parts of the mountains. The presence of human work and machines confirmed the feature of the child's mind described one hundred years ago by J. Piaget (2006, pp. 260-261) as technical artificialism. Another feature of the child's mind (also described by Piaget, 2006, pp.

110-120) was revealed by questions about snow on the mountain tops. The following explanation: *because it looks nice* was a reference to the aesthetic law, which at this stage dominated the physical law. Children explained the phenomenon by the selective activities of nature - *the wind blows in such a way that it takes snow from the slopes to the top*, or *snow only falls on the tops of the mountains*. At this level, children did not see the paradoxes of their explanations.

Simplified beliefs were the attempt of combining personal experiences and information obtained from adults. Since the confrontation took place while formulating explanations (cognitive activity), children began to be aware of having contradictory information or knowledge gaps. It happened that during the formulation of explanations, some children created a clarification on an ongoing basis. This way they were making a discovery (cf. Vosniadou & Brewer, 1992).

In the case of explaining the causes of volcanic eruptions, at this stage children focused on determining the temperature of lava. The key to solve the problem was not the scale unit but the term: *the hot lava*. Children found explanations for this phenomenon in the action of sun rays (probably related to personal experience) and the hot core of the Earth. On the basis of this (probably heard) information, they created a kind of a representation of the internal structure of the Earth. One of the ideas was an image in which volcanoes and the Earth's core were connected by a network of canals. This image (and probably the course of logical thinking that led to an explanation) resembled the Athanasius Kircher's 17th-century description of the inner structure of the Earth. He described the theory of the Earth's internal heat by stating that volcanic vents were connected to the Earth's core by a network of canals. Lava flowed through tunnels that distributed heat from the center of the Earth to the outside. This image was confirmed by the studies (Cardoso et al., 2018). This type of explanation also seemed to confirm the statement that the investigation of beliefs indicated some similarities to scientific historical theories (cf. Vosniadou and Brewer, 1992).

At the level of simplified explanations, the mountains formation turned out to consist in looking for natural causes (*the ground rises by itself*), but without knowing the facts related to the actual cause of this phenomenon. With regard to the snow on the mountain tops, the children correctly associated the process of snow heating and melting as the phenomenon of the snow disappearing from the slopes. However, they could not explain this physical law in a broader context. This confirmed the findings of Kelemen (1968, pp. 227-242) concerning the development of concepts among school children. He found that before children began to understand phenomena (at a scientific level), they had been giving reasons, knowing only the basic facts and laws but not being able to apply them in general.

The scientific level of explanations was especially difficult to achieve in the case of the phenomena, which had not been available through direct experiences (e.g. lava eruption, mountains formation and reasons for accumulation of snow on mountain peaks).

In the case of such phenomena, children had to give up their personal experiences and accept the (correct) explanations provided by adults. The difficulty resulted from very few experiences in such narrow areas of knowledge concerning the surrounding world as well as from the correctness of acquired information (Barnett et al, 2006).

In the case of explaining the volcanic eruption, the location of magma turned out to be the key problem. None of the children explained that magma came from the Earth's mantle. The reason was the poor knowledge of the internal structure of the Earth. Concerning the formation of mountains (four children), children provided information about the movement of tectonic plates. The statement that mountains were formed through their *contact*, probably came from some extracurricular sources of information. Children's beliefs became close to the scientific explanation, when they associated the low temperature with the accumulation of snow on the mountain tops. A small group of children was the sample research group. The research publication is intended to provide data for review studies. The results provided the impressive intellectual abilities of children who were just at the beginning of their school education. However, knowing the problems with cognition, it is possible to design appropriate learning situations and increase the effectiveness of lessons for children.

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DZIECIĘCA GEOLOGIA. ROZUMIENIE PRZEZ DZIECI 6, 7 I 8-LETNIE ZJAWISKA WYBUCHU WULKANU, POWSTAWANIA GÓR I ZALEGANIA ŚNIEGU NA SZCZYTACH

Streszczenie: Przetrwale błędne przekonania na wczesnych etapach nauki szkolnej mogą sprawiać, że dzieci mogą mieć trudności z przyjęciem naukowego wyjaśnienia. W artykule przedstawiono dziecięce przekonania odnoszące się do zjawiska wybuchu wulkanu, powstawania gór i utrzymywania się śniegu na szczytach. Badania przeprowadzono w formie indywidualnych rozmów z 50 dziećmi w wieku od 6. do 8. roku życia. Efektem ustaleń badawczych są przekonania dzieci uporządkowane od tych zawierających osobiste doświadczenia, przez te, w których dzieci uwzględniają informacje zasłyszane od dorosłych, po przekonania zbliżone do naukowych. Znajomość przekonań pozwoli nauczycielom lepiej dostosować organizowane sytuacje edukacyjne.

Słowa kluczowe: koncepcje dzieci, powstawanie gór, wybuch wulkanu

CHILDREN'S GEOLOGY. 6, 7 AND 8 YEAR-OLD CHILDREN'S UNDERSTANDING OF THE PHENOMENA OF VOLCANIC EXPLOSION, MOUNTAINS FORMATION AND ACCUMULATION OF SNOW ON MOUNTAIN PEAKS

Abstract: At the early stages of schooling, existing misconceptions may cause that children find difficulties in accepting scientific explanations. The article presents children's beliefs related to the phenomena of volcanic eruption, mountain formation and the accumulation of snow on mountain peaks. The research was conducted in the form of individual interviews with 50 children aged from 6 to 8 years old. The research results present children's beliefs, which have been arranged from those consisting of personal experiences, through those including information obtained from adults, to those being close to scientific explanations. The knowledge of these beliefs allows teachers to organize educational situations in a better way.

Keywords: concepts of children, mountains formation, volcanic eruption