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Educational Program "Thunderbolt Hunt": An Analysis with the "Experimental-Genetic Method"

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This paper attempts to transfer L.S. Vygotsky's experimental-genetic method in Science Education and, furthermore, into non-formal settings. The nature of Science Education in early school grades as well as the flexibility and the need to some extent of incorporating arts in Science Education indicate that experimental-genetic method may be applied as a useful tool of analysis which will provide in-depth insights about the learning process. The method was applied to the data, collected from the implementation of the educational program «Thunderbolt hunt» at the Archaeological Museum of Ioannina, Greece. Unlike many other courses, this educational program is based on the museums' exhibits and introduces concepts of science as well as cultivates scientific method. In this paper a meta-analysis of the implementation of the program to a first grade of a public primary school is presented. The data analysis shows explicitly the relation between the formation of the concept of air and the social relations and interactions between the students. The combination of transcending the misconceptions about air, conducting experiments and trying to adapt a new way of working result in a lot of contradictions while at the same time give space for reflection which altogether create «the dramatic character of the organized interaction».

Keywords: experimental-genetic method, non-formal setting, science education, pereghivanie.

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Introduction

This paper attempts to transfer experimental-genetic method and more specifically the approach of O. Rubtsova and H. Daniels (2016) in the field of science education considering the incorporation of drama and arts in science education. In the paper «The Concept of Drama in Vygotsky's Theory: Application in Research», the authors interpret Vygotsky's general genetic law of development considering the cultural-historical context in which the theory was developed, in light of the strong influence of Vygotsky's theatrical background on his ideas and the terminology he used. According to L.S. Vygotsky's general genetic law of development [17 as cited in 13]: «... any function in the child's cultural development appears on stage twice, that is, on two planes. It firstly appears on the social plane and then on a psychological plane. Firstly, among people as an interpsychological category and then within the child as an intra-psychological category. This is equally true with regard to voluntary attention, logical memory, the formation of concepts and the development of volition».

Researchers such as N.N. Veresov and M. Yaroshevsky have provided valid information about the Rus-

sian terms in Vygotsky's work which are hard to accurately translate into English. It is therefore clear, that the two planes to which Vygotsky refers, exist on the same stage [15] and when these two planes come to a point where they collide, due to the divergence between the personal understandings and the social situations, opportunities for development may appear [13]. Vygotsky, placing the «category» on a theatrical stage, expected that there will be conflicts, contradictions between the actors in terms of their social relations and that due to these contradictions the participants of the interaction will experience a «dramatic event», which will then «become the intra-personal category» [15].

The term «category» which appears in drama, involves «perezhivanie». Vygotsky [18 as cited in 13] describes the term as «the emotional experience [perezhivanie] arising from any situation or from an aspect of his [sic] environment, determines what kind of influence this situation will have on the child» focusing on the relations between an emotional experience as well as the situational characteristics which are also experienced [4]. M. Fleer [4] lists different ways in which the term «perezhivanie» is used in research, as a unity of emotions and cognition, which goes beyond the emotionally experienced situation itself and focuses on the child's consciousness and awareness of the situation, as a prism, that provides the lens which makes the relation between the child and the environment visible, as a unit of analysis, that refers to the characteristics of the whole which won't be corrupted and will retain their «properties inherent in the whole», as a double subjectivity in play/art, where the actors can be engaged in different emotional states on the stage, where one state may be connected with the feeling of performing, and another one can be the subject of his/her performance.

Children of young ages tend to relate with their social and material world emotionally [5]. In the field of science education, this is an important insight which could contribute to understanding students' experience and how they learn science by experiencing the interactions with and within their social and material world. Consequently, according to «perezhivanie», students' imagination, concept formation and emotions should be regarded as a unity, rather than perceived separately [5]. According to M. Fleer and N. Pramling [5], «... we conceptualize science education as an indivisible unity of what the child brings to activity setting in the preschool, the situational characteristics that are created by the teacher, as well as how these events are emotionally and conceptually experienced by the child. Together these represent the emotional experience of perezhivanie of the child's social situation of development.».

All the above is intensified if we consider science education in particular and STEM disciplines in general, as fruitful grounds to integrate arts. The literature highlights the advantages of integrating different forms of arts in STEM disciplines, for the promotion of innovation, creativity, critical thinking, cooperation, effective communication [11]. Especially in early childhood education, this approach seems even more appropriate given the students' needs of that age. Therefore, designing interventions or educational programs adopting an approach such as the "conceptual play worlds" which combine a plot, characters, drama, problem-solving situations and play [3] may be efficient for engaging students in learning and adopting a positive attitude towards science education [3; 10].

A brief overview of the research project

The research project described in this paper was conducted in 2017—2018 in Ioannina, a city in northwestern Greece. In the framework of the research an educational program was designed for the Archaeological Museum of Ioannina for students from 4 to 9 years old. The educational program, «Thunderbolt hunt» was offered to classes of public as well as of private schools of Ioannina. Unlike the rest of the museums' educational programs, it was introducing concepts of science education and cultivating scientific method, while at the same time it was designed based on the museums' exhibits and collections [7]. The idea was to combine cultural communication and science education enhancement with a long-term aim of developing a positive attitude to museum and science in students [10].

Description of the Educational Program «Thunderbolt hunt»

The educational program is designed to introduce scientific concepts in the framework of the cultural-historical activity theory. It differs from the typical educational programs, because it promotes scientific methods while at the same time it is designed to be implemented in museums of general interest. The design process of the proposed educational programs (SciEPIGI — Scientific Educational Programs for Informal settings of General Interest) incorporates a number of distinct characteristics/steps, including: 1. definition of the target group (age, level etc.), 2. connection of the museum exhibits with science education concepts, 3. link to the science education curriculum, 4. collaborative learning, 5. learning by doing, 6. balance between free choice and guidance, 7. instructor's role, 8. teacher's role [8]. This paper does not focus on the design process hence the above characteristics won't be further analyzed.

The educational program «Thunderbolt hunt» consists of 7 activities and lasts 90 minutes. There are activities that cultivate scientific method (2 & 4), games (6), activities which incorporate drama in education (5 & 7) and the plot of the program which introduces students to a problem-solving situation (3). The individual activities are briefly described below.

1. Group formation and discussion about museum exhibits: students are welcomed in the collection room «Dodoni». They are taking one card which illustrates an exhibit. The cards form three groups of students. A discussion takes place about the cards and what students think they represent.

2. Search for museum exhibits — The common element: the first task for the groups is to use the tools giv-

en (magnifiers, torches etc.) in order to find the exhibit which is illustrated in the group's cards and observe it. When all the groups find their exhibit, they describe it to the rest of the groups and altogether try to figure out the common element which is the thunderbolt.

3. How was the thunderbolt lost? — Narrative: this activity constitutes a narrative about Dodoni's oracle, which is pictured on the wall, and explains how Zeus lost his thunderbolt when Aeolus set his winds free from his sack without warning Zeus. Now Aeolus is accused, threatened for his life and ordered by Zeus to find the thunderbolt. Aeolus turns to students for help.

4. Experiments on air: the common element of activity 2 gives students the pass for the next task, which is the experiment about air and its properties. Students do the experiments by using the materials given in boxes (balloons, straws, syringes, plastic bottles with or without a hole etc.), test their hypotheses, communicate their findings, draw conclusions and gather data in order to help Aeolus by giving him advice on where and how to find the thunderbolt.

5. Role on the wall: students draw or write their advice and give it to Aeolus. He is pictured on a big paper and students glue their ideas on his head, so that he can think and choose the best idea to find the thunderbolt.

6. Zeus' winged thunderbolt: while he is as fast as the wind, Aeolus shortly and secretly leaves pieces of the thunderbolt to the instructor and students must assemble the pieces of the puzzle to get the Zeus' thunderbolt.

7. Aeolus' sack: Aeolus surprises students with the last task which is aimed at decompression. Before students leave the museum, they are asked to gather Aeolus' winds and put them back into his sack which is left to the instructor. When all the winds are in the sack one or more students tie the sack with a band, so that the winds don't escape [8].

Implementation

In this paper the implementation of the educational program for the 1st grade of the 24th Primary School of Ioannina is described. The numbers correspond to the individual activities of the program.

1. Students were speaking altogether. They were interrupting their classmates and they weren't following the rule of raising hands when they wanted to speak.

2. They were so impatient to start the activities that they didn't even let the instructor give instructions for the activity before they start. As a result, they were asking questions about the instructions of the activity after the activity had started. In the beginning, they were attracted by the tools (magnifiers, flashlight etc.), so they didn't immediately start observing the exhibits of the collection. They were getting excited when they were locating their group's exhibit in the collection, but soon, they were losing their interest on observing them in detail as they were instructed. Then, they were just expecting the next activity. The instructor had to encourage and motivate them to observe closely the exhibit, so they could find the common element when all the groups would share the characteristics of theirs.

3. They were making connections of the narrative with their everyday lives and they were associating life in Dodoni with elements of their own lives (the stadium, the city, the museum). They wanted to share with the instructor all the information they knew about Dodoni and its oracle, especially those who had recently visited Dodoni. At the end of the narrative, students were asking questions about the rest of the educational program and its activities and whether they would find a real thunderbolt in the museum, the one which was lost by Zeus. Then, they started questioning Zeus' power and discussing how weak he would be without his thunderbolt.

— Nefeli: If he didn't find his thunderbolt, he wouldn't be very strong anymore.

— Labros: Yes, without his thunderbolt he would be useless.

— Nefeli: He wouldn't be able even to strike.

— Iasonas: He wouldn't even be a God; he would become half-god without thunderbolt.

— Yorgos: He could change his power. He could take some fire from Hephaestus.

4. When the instructor gave the signal to find the boxes with the tools for the experiments, students started running around and they were getting very excited when they were finding their group's box. They were opening the boxes impatiently and they started using the experiments' materials without waiting to see whether the instructor would give further instructions. The instructor gave some time to students in order to look into the materials. A lot of students started using the materials unconsciously according to the experiments' process. Then, the instructor went through all the groups and motivated the students to conduct the experiments of the educational program. During this process, some students discovered new ways of using the tools (using the syringe or the straw to blow the balloon into the plastic bottle or placing the straw into the bottle's hole and pushing the balloon out of the bottles' lip). When they were conducting the experiments successfully, they were bragging about their achievements to their classmates or their teachers. Instructor's role especially in this part of the program was adjuvant. She was answering students' questions when it was necessary, and she was asking questions to students to promote scaffolding so that the students could expand their thinking and infer their observations from their experiments. As far as the rules of the community are concerned, students didn't successfully follow them while they were talking very loudly despite instructor's reminders. There were also conflicts among students while they were sharing the materials for the experiments. As a result, instructor kept reminding the rules of the community, particularly those about collaboration between the group's members. Apart from the violation of rules and the arguments, students were willing to share the results of their experiments and their group with their classmates or other groups.

5. The instructor gave the instructions for the activity. Students were listening carefully to the advice their

classmates gave to Aeolus and they were speaking only when the instructor gave them the floor. During the drawing though, students were again speaking loudly, and conflicts emerged among students who were sharing the same crayons. The instructor was interfering when conflicts appeared to soothe the tensions and remind the rule of collaborative working.

6. There were just a few pieces of the and all of the students wanted to take one and place it next to the others. As expected, this resulted in tension and complaints. The instructor assigned some students on assembling the pieces of the puzzle. Students were very excited when the puzzle was complete and asked their teachers to take a photo of them with the completed puzzle.

7. During the last activity students listened to the instructions and followed them properly. Of course, they all wanted to make the knot to shut Aeolus' sack and keep the winds imprisoned. Therefore, the tension wasn't missing, but the band used was big enough so most of the students could make a knot.

Data analysis

Before the implementation of the educational program, the instructor didn't have any information about the students' background. She only knew the school which they came from (public primary school) and the grade they attended (16 first-grade (6-year old) students). There was no need to learn more about the participants, since the methodology according to which the educational program was designed and analyzed, focuses on what happens when it happens. This paper constitutes a meta-analysis of the implementation of the educational program «Thunderbolt hunt» at the Archaeological Museum of Ioannina, with the aim of analyzing its activities from the perspective of the experimental-genetic method. The use of experimental-genetic method aims for an in-depth analysis considering the formation of the concept of air as an indivisible unit of the situational characteristics of the learning community.

The educational program «Thunderbolt hunt» approaches the concept of air through the experiments of the fourth activity which includes three different experiments. All the materials are put into boxes, therefore the materials for the individual experiments are not divided. Students can use all the materials at the same time, and this gives space for students to process and use them as they wish and imagine in the beginning/ Later the students are provided with further instructions and challenges.

1. The first experiment aims to introduce knowledge about the existence of air as well as that air takes the shape of the container it is in, by squeezing an empty plastic bottle or capturing air with an empty plastic bag.

2. The second experiment requires syringes that students use to understand that air occupies space and that it can be compressed. We challenge them to close the opening of the syringe and try to push the plunger.

3. The last experiment demands empty plastic bottles, some of them with a hole on the bottom. A balloon is placed in the spout of every bottle facing inwards and the students try to blow in order to inflate the balloon inside the bottle. This experiment approaches the property of air to occupy space and that two objects cannot occupy the same space at the same time.

The most important is that the experiments are conducted in a learning community that differs from the usual classroom, they are placed within a story that introduces a dramatic dimension to students and to a problem-solving situation and they are designed within a play-based frame [3].

It is very interesting to observe how the concept begins to shape in the trajectory of the experiments through discussion and interaction among students. We meet the concept for the first time when the instructor introduces to the students the incident with Aeolus and Zeus in Dodoni. When the concept comes up for the first time, the instructor asks students to share with her their ideas about air, what it is, where we can find it etc. The following extract shows how students react:

— We will learn something about air but why do you think we will do that?

— To find thunderbolt.

— Very well!

— Wherever is air there is rain and wherever is rain there is thunderbolt. (Dimitris)

— Very good. So, we will learn something about air to be able to help Aeolus to send his winds and find the thunderbolt. So, tell me, is there a way we can capture air? (instructor)

— No (a lot of students together)

— Please tell me one by one so I can hear you. Tell me Odyssey. (instructor)

— In something that will have no holes. (Odyssey)

— In something with no holes, tell me Yorgo.

— Something that won't have an exit. (Yorgos)

— For example, in here (the room), we couldn't because the air could escape (showing the corridor). (Giannis)

— We could in a vase. (Iasonas)

— In a vase, anyone else? Tell me. (instructor)

— In a box. (Sotiris)

— In a box, so according to what you say, if I take a bottle and close its cap very well, I can capture the air. (instructor)

— If you take a bottle then, you blow some air in it and then you close the cap. (Dimitris)

In the expert alternative conceptions appear about air that show a correlation between the existence of air and its movement identifying air with wind. We thus verify the fact that students tend to believe that a still bottle does not contain air unless we move it sharply and fill it with air. At this point the instructor doesn't try to sway students on the right direction. The instructor doesn't want to force them to change their ideas, but to support them in order to make their hypotheses, observe during the experiments and come to the conclusions desired based on their vivid experiences, rather than on the instructor's knowledge.

At this point is seems that the students' misconceptions about the air are regarded as a part of their current social situation of development. It is obvious, in

the above expert, that the students' opinions and beliefs about the air change when their classmates' opinion changes, which highlights the significance of social interactions in learning. It also confirms the need for the «collective form» since only then we can expect potential changes in the social situation of development, which in its turn, will hopefully lead to the development of higher psychological functions [13]. In the beginning, a lot of students agree that there is no way to capture air. When the first student opposes this observation suggesting that there is a way, the same students change their minds and suggest more options for capturing air building on their classmate's idea but carrying the misconceptions along with their ideas. Instructor's attitude towards the students' misconceptions is the key that will lead students to discovering the concept by interacting with their classmates and fighting their own limitations regarding the concept.

The next step leads the groups to the boxes with the materials for the experiments. After they have seen and used the materials freely, the instructor challenges the groups to try blowing the balloons in the bottles and pushing the syringe's plunger having syringe's opening closed with their finger.

Students then start using and playing with the materials and the instructor observes the process and intervenes only when it's needed taking the role of the mediator. The first thing that attracts the students' attention are the bottles with the balloons, probably because of the balloons. Some of the students succeed to inflate the balloons and some don't. Those who inflated the balloons are satisfied with the result and they subsequently brag about their accomplishment «I have strong lungs» Giannis says. Those who didn't make it are quite disappointed and start wondering what they are doing wrong. «Why doesn't mine inflate? » asks Eleni anxiously. The accomplishers then start showing to others the procedure, how they succeeded. «Look, take a deep breath and blow it» Andriana demonstrated and the rest try again harder but still they can't succeed. When it seems that they have lost interest, but still haven't figured out why this is happening, the instructor intervenes and suggests, giving a hint, to observe their bottles and see if they are all the same or they have any differences. Different ideas come from students such as the different size of the bottles, the different colors until some of the students spot the holes on the bottom of their bottles. The student who discovers the hole first starts sharing the observation with the instructor then with the rest of the group mates and with the rest of the groups. Then everyone searches for a hole in their bottles.

Here is the discussion between the instructor and one of the groups:

— I see Yorgos inflated the balloon, did the rest of you do it?

— No. (students)

— Why do you think is this happening? Is it because of the bottles, are there any differences between them? (instructor)

— This one has a hole (Yorgos)

— Oh, does it have a hole? (instructor surprised)

— I don't have a hole. (Mara)

— I will try to inflate it for you. (Adriana)

— Konstantina, does your bottle have a hole? (instructor)

— No (Konstantina)

— Can you inflate it? (instructor)

— No (Konstantina)

— So, what's happening, some of you can inflate the baloons, but some of you can't? (instructor)

— My bottle has a hole (Yorgos)

— Yours has a hole and why do you think it inflates? (instructor)

— Because the bottle has a hole (Yorgos)

— And what happens when it has a hole? (instructor)

— Miss, the air goes out. (Adriana)

— Oh, does the air escape from the hole? Is that what you mean Andriana? (instructor)

— While here it keeps the air inside and it can't be inflated. (Adriana while still trying to inflate Konstantina's balloon in a bottle without a hole)

— So, do you think that air takes up space and doesn't let the balloon inflate? (instructor)

— Yes (Yorgos, Konstantina)

— We have to make a hole on Konstantina's and Yorgos' bottles. (Adriana)

Sophia is still trying to inflate her balloon even though her bottle doesn't have a hole.

— Sophia, your bottle has no hole, it won't inflate. (Adriana)

While students try the experiment with the syringes, the discussions continue:

— Did you try to close the opening of the syringe and try to push the plunger? (instructor)

— Miss, it can't be pushed. (Angelica)

— Why? (instructor)

— Miss, I can't push it either. (Marina)

— I know, because it needs air to close the syringe. (Vangelis)

— You need air, you say?

— Miss, the air goes out. (Nefeli)

— If we close the hole? (instructor)

— It doesn't blow air. (Nefeli)

— So, what's inside the syringe? What doesn't come out of it? (instructor)

— The air! (Nefeli, Marina)

After the experiments, the boxes with the materials were gathered and put aside, and the instructor asked the groups to share their findings with the rest of the groups and classmates in order to draw some conclusions.

— Because the bottle has, it doesn't have a hole and the ... air doesn't leave. And I can't inflate the balloon because the air takes up all the space. (Dimitris)

— Well done, did you hear what Dimitris said? There is air inside the bottle and that is why the balloon does not inflate. Wait for your turn, Vasilis will tell us now. (instructor)

— If it's the bottle and it doesn't have a hole, the air can't go away, if it doesn't ... if it has a hole, the air will go away. (Vasilis)

— Hmmm, when it has a hole, the air leaves then ... (instructor)

— If it hasn't the air doesn't leave. (Katerina)

— If it hasn't the air doesn't leave. Odyssey, what did you want to add?

— When we try to inflate it (balloon), it does not inflate, if it has a hole (bottle) we inflate it and it can go down because the air leaves the hole. (Odyssey)

— Hmmm very well. So, do you think that air takes up space? (instructor)

— Yes. (Odyssey)

— So, the air takes up space in the bottle and that's why the balloon doesn't inflate. Very nice and tell me about the syringe, did you try to close the opening and push the plunger? (instructor)

— Yes! (a lot of students together)

— I tried it with ... (Maria)

— One by one, tell me one by one, otherwise I can't hear you. Tell me Rafaela.

— Miss, we tried, but it didn't turn out the way we wanted. (Rafaela)

— Wait for your turn Maria. Tell me Rafaela.

— With the syringe the balloon does not take air. (Rafaela)

— Did you try to use it as a pump? (instructor)

— The syringe doesn't work but with the straw it works. (Rafaela)

— Oh, you did it with the straw.

The last sentences of the extract refer to an alternative way of using the materials. Students, while they were freely using the materials, conducted their own experiments. They tried to use the syringes as pumps to inflate the balloons in the bottles. Using the syringe as a pump, students realized that even though the balloon was inflating a little, when they were trying to pump again the syringe sucked up the air back, hence the experiment was not successful. Using the straw instead was more successful but again they could not use it to fully inflate the balloon because the opening of the straw was very narrow.

What we can conclude from the fragments above, is that students, working in groups, shared their ideas, formed hypotheses which they next tested, conducted the experiments/ planned in the program, as well as their own experiments, and drew conclusions regarding the concept, following a specific way of working, which is collaborative, interactive and gives more space for the students imagination and freedom.

What is also very interesting in the present research is the different way of working in the learning community, beyond the concept formation itself. In order to present this way, we will describe below how the three structural components of the activity system, the learning community, the rules and the division of labor, appear while implementing the educational program. The description of these three components will give a clearer interpretation of how the learning community, the rules and the division of labor shape the new way of working which contradicts the students' prior experience of educational programs in the Archaeological museum of Ioannina.

Learning community is the environment in which Activity unfolds and tool mediation takes place while at the same time the socio-cultural context of Activity is intertwined [2]. Within the boundaries set by the community, the subjects are trained not individually but collectively through their participation in the learning community [12]. In the case of the present research, the learning community is located in the archaeological museum, where the educational programs are implemented, and the participants are involved in educational activities.

The Archaeological Museum is connected in students' minds with the objects exhibited there, with archaeologists' excavations and with the restrictions regarding the rules. Usually, students' visit in museums like the archaeological, include guided tour focusing on certain exhibits in relation to their historical features and usefulness in the past. On the contrary, the educational program «Thunderbolt hunt» incorporates different features from those of a typical guided tour. The latter is illustrated by the students themselves who took part in the program,

«Last time we came only for the exhibits, we did not come to play. (Yiannis); Wow we will play! Yes! (Many students together); Miss, will we take the bags? (Adriana referring to the bags with the observation tools after activity two); Shall we roll up our sleeves? (Adriana before the experiments); Miss, will we take these experiments with us? (Ioanna); Guys, we will play another game! (Yorgos); Miss, when will we play it again? (Iasonas referring to the second activity) ».

Despite the strict rules of the learning community with the proper design and management of the program by the instructor, the Archaeological Museum provided a flexible learning environment for cultivating students in scientific methods as well as bringing them in contact with authentic cultural objects hence providing them with multiple opportunities to construct and interpret meanings [16]. Multiple representations incorporated in learning communities such as museums, make learning, learning for all, offering a welcoming environment for different students. An indicative example, which emerges from the field notes, concerns the participation and interactions of «naughty» students. It seems that «naughty», according to their teachers, students responded very well to the activities of the program and introduced concepts crucial for the course of the program and the achievement of the object. Students such as Vangelis and Andriana, who were very active in the program's activities were considered by their teachers as «not good students». This would be very interesting for further study in relation to the current public educational system and how it meets the needs of today's students.

The **rules** in the learning community can be expressed either explicitly or implicitly and can affect in one way or another the use of tools in the implementation of the Activity [9]. In the case of the museum as a learning community, both obvious and implied rules are manifested. The obvious rules of the Archaeological Museum's learning community include restrictions on

the behavior of visitors to the museum, prohibition of touching the exhibits, low voice volume, being quiet in the area without running and pushing, non-consumption of food and beverages inside the museum. The rules that apply to students' participation in the museum's educational programs more or less include the rules that apply in the school classroom, such as respect for classmates, respect for teachers and instructors who conduct the program and moreover, teamwork and implementation of educational program activities according to the instructions. It is therefore clear that the rules are characterized not only by interpersonal but also by socio-cultural aspects [6].

There were a lot of points when students were not following the rules, especially in the beginning and the instructor kept reminding the rules to them. It is noteworthy that most of her reminders were made during the transition from one activity to the other, when students were looking forward to carrying out the next activity and they did not have the patience to listen to the instructions first. They wanted to know if the previous activity was the last one, if other similar activities will follow, if they would use the same materials and tools as well as if they could take them with them after leaving the museum.

In every activity system, the **division of labor** takes place in a specific way and indicates who does what in relation to the object, i.e. which members of the community are involved in which actions using tools [6]. During the design and the implementation of the educational program, effort was made so that the instructor is not represented as a person of authority to students. In order to avoid a strictly hierarchical community, the instructor's role to the division of labor was attempted to be limited by shifting part of it to students who undertook the division of labor within their groups. Therefore, the division of labor was carried out at multiple levels. There was division of labor on an individual level, within groups and in plenary.

Instructor's role as a mediator was to coordinate the individual activities undertaking the time management, the transition from the one activity to the other according to students' interest or once it was completed, the provision of instructions for implementing the activities, the provision of information about the exhibits, tools and experiments, answering students' questions with questions that can be tested, reminding community's rules when necessary and coordinating discussions. Students, on the other hand, collaborated in their groups with the rest groups as well as with each other in order to find the Zeus' thunderbolt in the Archaeological Museum, applying the rules of the learning community and following instructor's guidelines, they expressed their ideas, conducted the experiments, drew conclusions and undertook the division of labor within their groups.

Conclusions

Overall, in the beginning of the educational program, students were not listening to the instructor and they were not respecting the rules. The violation of the rules continued in the course of the program and only in the end students started to be more collaborative with their classmates. The duration of the program is quite short so we cannot conclude with certainty whether students' response to the new way of working would essentially change if the intervention was longer or repeated. It is obvious though that students are not used to work in these settings, which probably makes it hard for them.

If we can consider that students' difficulties in relation to the formation of the concept of air as well as the new way of working indicate the «current social situation of development», this novel way of working in the museum can be seen as the «first form of joint action». In this frame, all educational program's features, such as game-like activities, experiments and problem-solving situations can be considered «cultural means of transformation of social situation of development» according to the experimental-genetic method. That means that students gradually are moving beyond their boundaries by collaborating and following instructions.

According to O. Rubtsova and H. Daniels [13], what makes an intervention successful and leads the participants to positive changes is «the dramatic character of the organized interaction». The two ingredients to achieve the latter are conflict and reflection. The conflicts that emerge by the educational program's activities are on the one hand students' emotional involvement in the incident with Aeolus and Zeus within the storyline and the problem-solving situation (if we don't help Aeolus he may lose his life from Zeus' wrath) while on the other hand, it is the students' confrontation with their own misconceptions about air and their transcendence by doing the experiments and drawing conclusions based on their observations. All the above provokes students' emotional involvement in the course of the educational program and its game-like activities which result in emerging "contradictions, which trigger «pereghivanie» [13]. The reflective evaluation of students applies here in several parts of the program. Every activity of the educational program starts and ends with a discussion during which students have the time to express their ideas about the exhibits, Dodoni, the story, the concept of air, to make connections with their everyday lives, to form hypotheses, communicate their observations, draw conclusions and all of these discussions help them to review their situation of social interaction and reconsider their opinions and points of view [14 as cited in 13]. Another action that helps students to reflect on their experience is making the drawings in activity 6, the role on the wall, where they can revisit their experiences and activities and share with Aeolus their inner thoughts and ideas that will lead him to the solution of his problem.

All in all, the experimental-genetic method seems an appropriate tool of analysis for interventions in the field of science education in early grades and, furthermore, in non-formal education. It can provide useful insights about the learning process of young students and it can be further tested towards a more systematic use in research.

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Образовательная программа «В поисках молнии Зевса»: анализ средствами экспериментально-генетического метода

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В статье описана попытка применения экспериментально-генетического метода Л.С. Выготского в контексте обучения естественнонаучным дисциплинам в школе и в неформальной обстановке музея. Характер курса по естественным наукам в начальной школе, а также необходимость гибкого его выстраивания и включения в него элементов творчества указывают на то, что экспериментально-генетический метод может выступать важным инструментом анализа, позволяющим получить содержательную информацию о процессе обучения. Мы использовали этот метод для анализа данных, полученных в ходе реализации образовательной программы «В поисках молнии Зевса» в Археологическом музее Янины в Греции. В отличие от других, эта образовательная программа вводит научные понятия и приобщает детей к научному методу, одновременно знакомя их с экспозицией музея. В настоящей статье представлен метаанализ реализации программы в 1-м классе государственной школы. Полученные данные ясно свидетельствуют о наличии взаимосвязи между формированием

понятия «воздух» и социальными отношениями и взаимодействиями между школьниками. Выход за рамки ошибочных, житейских представлений о воздухе в процессе проведения экспериментов и попытка приспособиться к новому способу деятельности приводят к целому ряду противоречий, но в то же время оставляют пространство для рефлексии, создавая в совокупности «драматический характер организованного взаимодействия».

Ключевые слова: экспериментально-генетический метод, неформальный, естественнонаучное образование, переживание.

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