The STEAM explorers of spring

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Abstract

In this paper we studied the Spring season both in its scientific dimension (Physics, Mathematics, Geography, Engineering) and in its artistic perspective (Music, Painting). We used ICT tools (Excel, Scratch, Paint 3D, Microsoft Sway, Microsoft Photos, Wordwall, Google Forms, Book Creator, CmapTools, Movie Maker) in the realization of a number of activities which were held in the classroom. These activities involved students from a primary and a secondary school, and were completed in 12 teaching hours. The students, working in groups, interdisciplinary, utilizing both the theory of constructivism and the theory of discovery learning, participated actively in approaching the various aspects of Spring, fulfilling cognitive, emotional and psychomotor objectives. They became protagonists as they were transformed into painters, poets, musicians, body percussionists, young scientists (engineers, physicists, geographers, mathematicians, programmers), learning in a pleasant, creative and very effective way.

Keywords: *constructivism, discovery learning, Spring, STEAM*

Introduction

The «STEM» term is the acronym of Science, Technology, Mechanics and Mathematics. However, something is missing from this apparently complete sequence… It is the first letter of the alphabet, the "A" which reminds us the word Arts. A letter which was added to the word STEM and transformed it lexically into a "steam" of motion, highlighting the coexistence of sciences and arts throughout the creative route of the human civilization. This reciprocal truth of sciences with the emotion and beauty of arts was our main educational proposal presented in this paper. Our experience from the Greek educational system reveals that unfortunately the above interdisciplinary approach is missing.

Dewey used to say "the real process of education should be the process of learning to think through the application of real problems". Connection of school knowledge to everyday experience is also absent from the school reality. So, the activities we organized were planned to fill this emptiness.

Mary Poppins, the heroine of the famous blockbuster, said: "In every job that needs to be done, there is an element of fun. Find the fun and work became play!" (Werbach, 2016a; 2016b). This is exactly the goal of gamification: to give various tasks a sense of play. Following her advice, we promoted gamification and fun which unfortunately are incriminated into the school curricula.

Our paper is addressed to the last grades of a primary and the first ones of a secondary school. It was realized during 12 school hours per class, by music and science teachers, at 2 different schools.

Main goal

The main goal of the project was the students to follow an interdisciplinary approach – STEAM education - of the season of Spring.

Objectives

Cognitive objectives

- learn about Antonio Vivaldi and his most popular composition "Spring", one of his "Four Seasons"
- get to know visually and acoustically the strings with bow (i.e., the violin family) and the cembalo

- learn traditional Greek customs related to the spring coming
- perceive how to create lyrics over a rhythm
- study and create scientific graphs
- become familiar with the use of scientific models and simulations
- practice in transiting from the macrocosm to the wonderful world of microcosm
- apply the acquired knowledge to new real-world situations
- develop their imagination and critical competences.

Emotional and psychomotor objectives
- give life to the emotions emerged during the listening process, with movements and "frozen" images
- motivate students to express themselves and become creative
- derive pleasure from the activities
- cultivate a cooperative spirit and work as a team to achieve a goal
- enjoy the beauty of nature, as it is imprinted on paintings.

ICT objectives
- become familiar with internet searching
- practice how to create an attractive presentation based on their research findings
- become familiar with digital tools such as *Microsoft Excel, Paint 3D, Movie Maker* etc
- understand that ICT are not only used for entertainment and communication, but for educational purposes, too.

Theoretical framework
The project was based on the pedagogical methods of constructivism and discovery learning.

Constructivism
According to constructivism, knowledge begins to be constructed spontaneously and actively by each individual, long before someone is taught something in a systematic way at school, through personal or social activities as one tries to understand and interpret the world. These spontaneous cognitive patterns form coherent networks between them that are described by the term "mental models" (Driver et al., 1993; Κουλαϊδής, 1994).

The constructivism typical phases of teaching are (Driver & Oldham, 1986): Orientation, Emergence and clarification of students' perceptions (Κόκκοτας, 2002), Conceptual correlation of old and new concepts and their reconstruction/enrichment (Lemeignan & Weil-Barais, 1997), Application to new situations and feedback (Ollerenshaw & Ritchie, 1993), Reflection on the learning process.

Discovery learning theory
According to this theory (Bruner, 1961), teaching does not mean inserting knowledge into someone's mind, but teaching him/her to participate in the process of knowledge construction through experimentation and practice, within a grid of social-type interactions. Hence, learning is sustained for a longer period (Πασσάκου, 1973).

Methodology
Cooperative learning: Team members could exchange information and ideas, identify weaknesses and face them (Johnson & Johnson, 1994). Teams motivate their members and give them the impulse to work together for the common goal (Slavin, 1990).

Interdisciplinary approach – STEAM: The project involved, apart from the STEAM disciplinary, the subjects of History and modern Greek Language.

Experiential activities: Experientialism and active participation are very important factors for a successful educational process, combining knowledge and entertainment: more action than words, rather action than passivity.

ICT: Approaching a school topic in a modern, attractive and enjoyable way, motivates students to get involved actively and critically in the teaching process. After all, "study without desire blocks memory which becomes unable to retain the incoming knowledge", as Leonardo da Vinci used to say. New Technologies act in this way as they enrich the school lesson with multimedia material, create multiple representations for students in order to motivate them and facilitate the consolidation of knowledge.

Observation: Observing the result of an experiment, modelling and/or graph helps students to understand properties and interactions of bodies. Thus, observation can be used in student-centered teaching, as a basis of the attempt to explain these interactions at a more theoretical level, and then moving from the more perceptual macroscopic level to the microscopic one.

Realization of the project: part 1 - music activities
The first step was stimulation. Our students watched a *PowerPoint* presentation with paintings inspired by Spring and they were mobilized to unfold ideas, emotions and imagination. Then they listened to "Spring" of Vivaldi's "Four Seasons".

Afterwards, questions were asked as brainstorming: "What do you see? What are you thinking? What strikes you? What colours prevail? Does a song or a poem come to your mind?"

Then, they were asked if music can describe images and sounds from nature and they were urged to imitate these sounds with their voice and body. They described the feelings that this season evokes and wrote symbols (swallows, flowers, butterflies) and key words relevant to our theme.

Consequently, the students were divided into four groups.

Group 1 searched information about the technical part of the music piece, i.e. what genre it belongs to, what a concerto is, what a string quartet is and which instruments are used.
The 2nd group inquired about the composer's life and work.
The 3rd group discovered different versions (rock, e.t.c.) of the music piece.
The 4th group "summoned" Spring with the "Chelidonismata", the Greek carols of Spring, and the traditional custom of "the Pirpirouna".
The groups worked on their topic by conducting research on suggested web addresses, making this procedure safer, easier and faster. Their findings were shared on *Google Docs*.

Synthesis and record of information - presentation
The teams selected and synthesized the information they had gathered, combining text, images, video and sound. They created the following outcomes:

- e-book for Vivaldi and his "Spring", by using the *Book Creator* application

(https://read.bookcreator.com/xXG40qJSEYakdl3PFsm2QiXEdwx2/qD9itmoPTHqY3ztB8yRn2w).

- Creating a book enhances students' creativity and promotes their imagination. It greatly helps them to cultivate critical thinking as they are asked to make decisions about the content and the design of the book and to manage the provided digital tools. They practice writing through an enjoyable and rewarding process as they know that their work will be published.

- Conceptual map using *CmapTools*, in order to understand the musical form of Rondo. The students, after dividing the melody into nine smaller parts, related the form of each part to pictures. They placed the composer as the central figure, and the nine images that show the rhythm of the melody, around him.

- *Microsoft Sway* presentation. The students narrated digitally the "Chelidonismata", the Greek carols of Spring, using *Microsoft Sway*. This creation is at the following link: https://sway.office.com/pcpnpuKwIGsSZcRZ?ref=Link

Presentation digital apps enable students to look for ways to bring their ideas to life in the most effective and attractive way. After all, according to the UNESCO pedagogical framework, one of the 21st-century educational skills is the ability to present and communicate our ideas, which aims students to strengthen critical thinking and creativity (Common Sense Education, 2016).

The groups presented their creations to the whole class in order to provide the necessary feedback and evaluation.

Knowledge games

- With the digital tool *Wordwall*, the students created a wordsearch with words and musical terms related to Antonio Vivaldi's "Spring" (https://wordwall.net/resource/55062471). Wordsearch is a learning tool as it enhances spatial perception and helps its users to enrich vocabulary, correct spelling of words, concentration and observation.

- They experimented with *Google Forms* and created a quiz with the information they had collected about the composer and his work https://docs.google.com/forms/d/e/1FAIpQLSc9t6o4kRkwXyFA3n5dBmuAwp9b-F5sBzrQwdnwM2FuKjD_3g/viewform?usp=sf_link. By engaging students with digital quizzes, in addition to developing digital skills, we offer them direct self-assessment, in the framework of "what I have finally learned and what I have not learned".

- In *Microsoft Word* they constructed acrostic poems with the letters of the words: Spring, Vivaldi, Swallows, March. This creative writing activity enhances communication, reveals cognitive skills and encourages students' self-activity.

- *SCRATCH*. Studying the musical score of "Spring" gave us the idea to create our own digital piano and play music with the online programming application *Scratch* (https://scratch.mit.edu/projects/518854682). With music creation software, students experiment, explore musical material, test and have direct visual and auditory feedback for their creation, and develop listening skills (Gall & Breeze, 2005). Thus, even students who do not

afford a musical instrument are encouraged to play or, even more, to compose music. In this way, financial scarcity is not a barrier, as all students have equal opportunities to learn.

- *Microsoft Photos*. We draw images of Spring. Our creations were digitized and we made photo and video albums (https://drive.google.com/file/d/16WJcJettt6XDf0cb0vDA9UY_bvK8Cgpa/view?usp=sharing). Through painting, students imprint their thoughts, feelings and concerns, cultivate creativity and imagination and stimulate all their senses.

- Play music using our body. Following the rhythm of Antonio Vivaldi's music, the students used their feet, hands and their own bodies to play music (body percussion). Then, they gave life to the change of seasons and played a musical-motor game entitled "nests and swallows". Activities that involve movement encourage students' experiential participation. This procedure enhances rhythmic perception, perception of space, acquisition of motor skills and experiences, development of musical memory and cultivation of expressiveness and creativity. In addition, students communicate in a different way than verbally, as music itself is a carrier of ideas and emotions.

- The students started writing cooperatively their own poem. They made lyrics by rhyming the proper words, in order to match to the melody. Poetry activates imagination and emotion as it forms images of carefully chosen words, enriches vocabulary and intonation of words, entertains, creates listeners, contributes to children's emotional development.

- A «peculiar» musical score. Graphic scores are a different way of writing music, as they do not need a pentagram, keys, notes, pauses. The students used signs, colours and symbols to create a graphic representation of the melody of Spring. This is a clever and amusing way to cultivate students' rhythmic ability as they discover the rhythm of a music piece and transform it into music through their own musical score. Graphic representations play an important role in music education and serves as a starting point for learning, listening and performance strategies (Tan & Kelly, 2004).

Realization of the project, part 2 - science activities
Using the pedagogical method of constructivism, we held the following activities:

Alternation of seasons: physics and geography
Orientation: after listening to Vivaldi's "Spring", we oriented ourselves to the study of Spring.

Emergence and clarification of students' perceptions: using the discussion and response elicitation techniques, we collected our students' spontaneous responses about the cause of season switching. The students answered that this phenomenon is due to the alteration of Earth's distance from Sun: in winter this distance is large so cold prevails on Earth, while in summer it is short so the air temperature is high.

Creating cognitive destabilization and perception reconstructing: 'Why does winter overrule in one hemisphere and summer in the other at the same time, while the Earth-Sun distance is the same for both hemispheres?" The students could not answer

this question so we constructed the following model (Allaby, 1995): Earth was represented by a ping-pong ball, the axis of Earth by a stick, and Sun by a lamp. The students were guided to discover the correlation of the Earth-axis tilt with the plane of its orbit around Sun.

Application to new situations and feedback: we had already created a video, using the app *PowToon*, about the season switching (https://www.youtube.com/watch?v=z8f9blkGLJc). The students studied the video and were asked to answer the questions: i) why a summer day at the poles lasts 24 hours, while in winter Sun does not rise at all, ii) why at the equator the day has the same duration as the night, during all the year, iii) whether season switching happens on the other planets of our solar system, too.

Reflection on the learning process: worksheet with questions: i) What did you initially think about the cause of season switching? ii) What made you change your mind? iii) Why there are different seasons on the two hemispheres at the same time?

Swallow nests: mechanics and physics
Orientation: the spring carols and the musical-motor game about the nests gave us the motivation to study the construction of a swallow nest.

Emergence and clarification students' perceptions: using the brainstorming technique, we collected students' spontaneous responses regarding the materials, size, shape and the most appropriate location of a swallow nest. The majority of the students, having already seen nests since they came from semi-urban and rural areas, answered the above questions correctly, except for the birds' saliva and the choice of the nest shape.

Identification of correlations between old and new cognitive patterns and enrichment of perceptions: as the old cognitive patterns were not incorrect and they only needed completion, the observation method was used: after watching a video about nest building (masterx201, 2016), they filled in a worksheet which contained the same questions with the previous step.

Application to new situations and feedback: the secondary school students created a 3D swallow nest (https://drive.google.com/file/d/1i7KVSYB62uSW2gtyqIqmVaEKbxHmRCdI/view?usp=sharing) using *Paint 3D* for its construction and *Movie Maker* for its presentation, and the little students a tangible one (https://docs.google.com/presentation/d/1dmhpOFUSi-vagEuoqGIKaeEDejCgypH_/edit?usp=sharing&ouid=100988640825647378933&rtpof=true&sd=true), as feedback of what they had already learned.

In order to apply the acquired knowledge, they were asked to match straw, soil and the swallow saliva, with the materials for the construction of both primitive and modern human dwellings.

At the microscopic level, they perceived that the adhesion forces between molecules of different bodies have an attractive nature. Then, they were asked to explain: i) capillarity, in order to explain how plants get their nutrients from soil, ii) why raindrops "stick" on the glass and honey on the spoon, and iii) why we manage to stay upright when we walk, without slipping.

Reflection on the learning process: the worksheet contained the following questions: i) What did you initially think about the materials of a swallow nest? ii) During these activities, did you discover the use of other materials? (iii) Which force is responsible for both the construction of a swallow nest and the reception by a plant of its nutrients from the soil?

Vernal rainfall: ICT and mathematics
Orientation: motivated by the traditional Greek custom of Pirpirouna, we decided to study the vernal rainfalls. The kids studied photographs (Ahrens, 2013) and videos (ZoneA, 2017) of the main categories of clouds and identified the ones which are accompanied by rain.

Emergence and clarification students' perceptions: using the technique of predicting the evolution of a physical phenomenon, our students were asked whether they believed that the amount of rainfall during the vernal months varies from year to year. Having in mind climate change, they replied that anthropogenic warming of the atmosphere causes drought and therefore a rainfall reduction.

Creating cognitive destabilization and reconstructing perceptions: the Hellenic National Meteorological Service provided us with monthly rainfall data from weather stations of our regions, for a 23-year period. Then, we gave our students instructions for the construction of graphs in *Microsoft Excel*. Thus, they managed to plot the amounts of the vernal rainfall (https://drive.google.com/file/d/128bfM4xPSoU_l0-UrvNn4izct1Mf8um3/view?usp=sharing) and were asked to comment on these graphs and investigate evidence of the existence of climate change.

Application to new situations and feedback: the students were asked to plot and study rainfall of the rest of the months, thus obtaining confidence to work in *Excel* and to use Mathematics in real-life problems. They also plotted the monthly temperatures for long-time periods in order to study their temporal behavior.

Reflection on the learning process: the students answered the questionnaire: i) Did you originally think that rain during the spring months becomes more frequent, from year to year? ii) How did studying of the graphs change your mind? iii) Based on the aforementioned graphs, do you conclude climate change?

Conclusions
When the activities were completed, all the students were given a questionnaire to evaluate the whole process. They were asked if they liked the interdisciplinary approach of our theme, which activities were the most and the less interesting ones, what they would suggest us to change, what was difficult for them. Hence, failures and problems were identified, so we were able to make the necessary improvements for a future use.

The above-mentioned questionnaire confirmed that children liked intersubjectivity, showing us the way to enrich the educational process and integrate the curricular programs (Καλδή & Κόνσολας, 2016). Interdisciplinary method sparked students' interest and maximized the enjoyment of both creativity and free expression.

The answers of the questionnaire also highlighted that the playful nature of the majority of the activities was an attractive factor for the students, strengthening their verbal and emotional development, but also their willingness to seek, compare and analyse information, experiment, create, innovate and mature.

Students' participation in all the activities was universal. The questionnaire also pointed out the children's willingness to perform activities that involved movement following the rhythm of music.

The students' continuous collaboration inside the groups contributed to their socialization, confirming that cooperative learning strengthens the group members' positive interdependence and promotes collegiality in the educational process (Κογκούλης, 2011). A lot of times the students of the 2 schools worked together and they managed to communicate effectively even though they were from different level.

Another point that emerged and is worth emphasizing is that the children found interesting and useful the connection of the knowledge they acquired with real phenomena and situations. This process integrated their new cognitive schemas with their old ones, but also increased their confidence that they were able to interpret in a better way the world around them.

On the other hand, the answers of the questionnaire revealed the students' difficulty in constructing and studying graphic representations, and in designing the presentation of their work. They said that they needed more time for these activities, even though they worked a lot at home, on their own.

Conclusively, this paper proposes the cooperation of teachers from different specialties in order to form cooperative structures that will reform their sealed framework, and the placement of experience in a leading position as the learning effort must start from experience and end to experience.

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