D3.1.x CREATIONS SUMMER SCHOOL

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Table of Contents

1 Introduction / Demonstrator Identity

1.1 Subject Domain

Astroparticle physics, history of the Universe.

1.2 Type of Activity

Summer school for students including lectures, workshops, visits to Research Infrastructure (physical visits/ virtual visits), use of online analysis tool, science café, public presentations, short theater Play and performance. The activity can be characterised as a Small scale Activity at local or national level.

1.3 Duration

5 days

1.4 Setting (formal / informal learning)

Both formal and informal setting. Students work in school classes & labs, visit research centers (physically or virtually), perform on theater stages etc.

1.5 Effective Learning Environment

- Communities of practice (Students groups)
- Dialogic space / argumentation (Science café)
- Arts - based
- Experimentation (Science laboratories and eScience applications)
- Simulations (digital/physical, computer labs)
- Visits to research centres (virtual/physical)
- Communication of scientific ideas to audience (theater stage)

2 Rational of the Activity / Educational Approach

2.1 Challenge

Astroparticle and High Energy Physics is a domain of science that is between top priorities of cutting edge research. Questions like, "what are the basic building blocks of matter?", "What are the fundamental forces of nature?", "Could there be a greater underlying symmetry to our universe?", still remain to be answered. Particles such as neutrinos or Higgs bosons are expected by revealing their secrets to play a major role in putting the pieces of the puzzle in the right places and tell us the history of the universe.

More specifically neutrino's particular features and properties, combined with the fact that its mass is very small, nearly zero, offer neutrino a unique advance to carry the information regarding its generating point, unchanged, at enormous distances. Furthermore neutrinos penetrate matter without being absorbed. Therefore, the information they transfer may be from interior of the celestial bodies. On the other hand, Higgs boson interacts with both bosons (particles that carry fundamental forces) and fermions (particles that make up matter), confirming the prediction by the Standard Model that all elementary particles acquire mass via the all-pervasive Higgs field. The stronger a particle interacts with the Higgs field, the heavier is. Without mass, atoms would not exist. Discovery of the Higgs boson has opened up whole new windows in the search for new physics.

Concepts as these described above, usually are not studied thoroughly or even included in the curriculum. In this framework the challenge in which this demonstrator responds to, is the creation of an activity at both an in & out of school context, such as a summer school for students, based on merging different CREATIONS demonstrators. Basic object of the summer school is to get students in contact with complex science subjects, how scientists work and inquiry based learning, using formal and informal science education tools (e.g. school labs, visit to research centers) combined with art (e.g. storytelling, performance), raising at the same time the interest of students in science and art as well.

2.2 Added Value

Summer school is a scheme that could add value to the existing (or future) initiatives and demonstrators of CREATIONS project. Due to its nature, which incorporates elements from both formal and informal settings, summer school curriculum can take advantage of a variety of practices and tools which included in CREATIONS demonstrators according to its learning objectives and outcomes. For instance Messini summer school used and combined practices from "Learning Science Through Theatre", "CMS virtual visits" and "Hypatia" demonstrator. In addition a summer school activity can act as starting point for further activities at national or international level.

3 Learning Objectives

3.1 Domain specific objectives

- To introduce students to Astroparticle physics concepts such as neutrinos, Higgs boson, neutrinos' telescopes, etc.
- To introduce students to the concept of gravitational waves.
- To introduce students to the History and evolution of the universe.
- To introduce students to the way a researcher works in the field of Astroparticle and High Energy physics.
- To guide and support students, create and present their own science stories (regarding their acquired knowledge) in form of short plays.
- To engage students in simulated robotics problems relevant to the educational scenario of the summer school.
- To introduce and support students to develop solutions using the Scratch visual programming language.

3.2 General skills objectives

Students will be able to :

- Engage in scientifically oriented questions.
- Give priority to evidence in responding to questions.
- Formulate explanations from evidence.
- Connect explanations to scientific knowledge.
- Communicate and justifies explanations using creative approaches via art based activities
- Work collaboratively as members of a team

4 Demonstrator characteristics and Needs of Students

4.1 Aim of the demonstrator

The main aims of the demonstrator is

- To introduce students in complex science topics.
- To present the connection between Micro Cosmos and Cosmos.
- To introduce students to the way science research is conducted.
- To present alternative approaches.
- To engage students that have different interests, in science.
- To combine art and science in an effective way, enhancing the creative thinking of students.

4.2 Student needs addressed

This Summer school demonstrator aims to satisfactorily address to numerous recognised students' needs such as:

- Curiosity and interest concerning major science subjects such as the birth and the evolution of the universe.
- Familiarize with Inquiry based learning process
- Collaborative learning.
- Enhance creativity and imagination.
- Communicate effectively their acquired knowledge.
- Identification with scientists and researchers as professional role models

5 Learning Activities & Effective Learning Environments

Science topic: **Astroparticle physics, particles accelerators, History of the Universe.** Relevance to national curriculum: **Collision, momentum conservation, waves interference, dual nature of mutter (wave-particle).** Class information Year Group: **Senior high school.** Age range: **16-18** Sex: **Both.** Pupil Ability: **The scenario allows space for pupils of various abilities to participate.**	Materials and Resources *What do you need? (e.g. printed questionnaires, teleconference, etc.)* **Lecture room with projector, teleconference platform, space for computer lab, space for experimentation, transportation.** *Where will the learning take place? On site or off site? In several spaces? (e.g. science laboratory, drama space etc.), or one?* **In school classes or lecture halls, school labs, in research centers (physically or virtually), in places relevant to art (e.g. theaters), In public science café** *Health and Safety implications?* **None** *Technology?* **- Computers with internet access, projector and basic video conferencing equipment.** *Teacher support?* **Lecturers of the presentations or facilitators of the workshops are responsible for each day teoritical/practical activities of the summer school.**
Prior pupil knowledge: **Advanced level of knowledge in Physics. Basic understanding of elementary particles and electromagnetism**	

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Individual session project objectives *(What do you want pupils to know and understand by the end of the lesson?)*

Day 1: Students will learn about the elementary particles, standard models, history of the Universe and the connection between Micro cosmos and Cosmos.

Day 2: Students will learn about important principles of high energy physics, subatomic particles and the structure of matter. Secondly they will learn how to work like actual researchers by evaluating and analyzing real data from the ATLAS experiment at CERN. They will visit virtually a large infrastructure research institute (CERN- ATLAS EXPERIMENT) at learn about the science, engineering and technology involved in particle physics experiments. Also they will visit physically an Astroparticle research institute (NESTOR at Pylos) and learn about about neutrinos' detection and how science researchers in the field of Astroparticle physics work.

Day 3: Students will learn about the properties of gravitational waves and the information they carry. Furthermore they will start to learn how to develop short science stories in order to communicate their acquired knowledge.

Day 4: Students will learn about how particle accelerators work. Also students will engage in simulated robotics problems and learn how to develop solutions using the Scratch visual programming language. Furthermore they will start to create a short play from the science story they developed.

Day 5: Students will learn about basic principles of science communication and the will finalize their short play in order to perform it and communicate their new knowledge.

Assessment	**Differentiation**	**Key Concepts and Terminology**
The short science stories created by the students and their acting performance will be analyzed and will work as an assessment tool. Additionally the acquired knowledge and skills by the students can be checked through briefs questionnaires.	*How can the activities be adapted to the needs of individual pupils?* Activities can be customized to the students' learning needs according their age as well as their prior knowledge and native language.	Science terminology: **Neutrino, Higgs boson, gravitational waves, particles detector, accelerator, GeV, hadrons, leptons, particle collisions, Standard model, Big Bang.** Arts terminology: **science stories, short plays, script, performance, acting, sketches**

Session Objectives: During this scenario, students will be introduced to advance scientific knowledge concerning elementary particles, the Higgs boson and gravitational waves either. Students will also learn to investigate scientific questions using the steps of inquiry learning process. Additionally they will gain notable programming experience and get familiar with concept such as data collection and processing, the role of sensors in a robot, control of its function Finally they will learn to use creative approaches in order to communicate this knowledge learning.				
Learning activities in terms of CREATIONS Approach				
IBSE Activity	**Interaction with CREATIONs Features**	**Student**	**Teacher**	**Potential arts activity**
Phase 1: **QUESTION:** students investigate a scientifically oriented question	Students pose, select, or are given a scientifically oriented question to investigate. *Balance and navigation* through *dialogue* aids teachers and students in creatively navigating educational tensions, including between open and structured approaches to IBSE. Questions may arise through *dialogue* between students' scientific knowledge and the scientific knowledge of professional scientists and science educators, or through *dialogue* with different ways of knowledge inspired by *interdisciplinarity* and personal, embodied learning. *Ethics and trusteeship* is an important consideration in experimental design and collaborative work, as well as in the initial choice of question.	**1.** Students engage in dialogue with teacher/lecturer Through this discussion, students along with the help of the teacher, pose investigative questions. For example, How we can see back in time? Is light the best way? Are neutrinos an option? Are gravitational waves an alternative?	**1.** Teacher/ lecturer delivers a lecture to the students regarding the History of the universe. Dialogue on the evolution of the universe with the student begins.	

Phase 2: **EVIDENCE:** students give priority to evidence	Students determine or are guided to evidence/data, which may come from *individual, collaborative and communal activity* such as practical work, or from sources such as data from professional scientific activity or from other contexts. *Risk, immersion and play* is crucial in *empowering* pupils to generate, question and discuss evidence.	**1**. Students gather evidence regarding the LHC accelerator, the discoveries it made about the elementary particles and how they can be classified in families. **2.** Researchers are discussing with students physically or virtually, presenting their work. Students gather evidence **3**. Students gather evidence about gravitational waves.	**1.** Teacher/facilitator delivers presentations regarding principles of high energy, physics subatomic particles, accelerators etc. **2.** Teacher/facilitator organizes physical or virtual visits to large infrastructure research institutes (CERN/ATLAS Experiment-NESTOR/Neutrinos detection). **3**. Teacher/facilitator presents ISE Learning Scenario: **Gravitational Waves in Class** concerning the gravitational waves and their properties. **4.** Teacher/facilitator organizes a public science café.	

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		4. Student listen to the argumentation and gather evidence.		
Phase 3: **ANALYSE:** students analyse evidence	Students analyse evidence, using *dialogue* with each other and the teacher to support their developing understanding.	**1.** Students use the HYPATIA tool and examine a number of actual events that were detected by the ATLAS experiment. Based on the evidence they have gathered before, they analyze the events, they recognize different tracks of muons comparing to electrons and finally they "discover" the Higgs boson. Students analyze the information they gathered concerning	**1.** Teacher/facilitator help students to use HYPATIA tool, answer to student questions and provide the needed clarification.	

		gravitational waves.		
Phase 4: **EXPLAIN:** students formulate an explanation based on evidence	Students use evidence they have generated and analysed to consider *possibilities* for explanations that are original to them. They use argumentation and *dialogue* to decide on the relative merits of the explanations they formulate, *playing* with ideas.	**1.** Students discuss their findings from the previous phase and decide which of their results are valid. **2.** Students collaborate in teams and choose the explanations they will adopt regarding the investigative questions that have been posed and then they proceed with the development of the science stories .	**1.** Teacher/facilitator helps students to interpret their findings. **2.** Teacher/facilitator helps students identify possible misconceptions.	Creation of science stories by the students, storytelling, script writing.
Phase 5: **CONNECT:** Students	Students connect their explanations with scientific knowledge, using *different ways of thinking and knowing* ('knowing that', 'knowing how', and 'knowing this') to relate their ideas to both	**1.** Students discuss their results and the conclusion they	**1.** Teacher/facilitator	Acting, script writing,

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connect explanations to scientific knowledge	disciplinary knowledge and to *interdisciplinary* knowledge to understand the origin of their ideas and reflect on the strength of their evidence and explanations in relation to the original question.	reach, in comparison with already known and reliable data and facts in the science literature. **2.** Also students make the connection of the science stories they develop with other disciplines such as script writing, acting, directing and start to convert their story into a short play.	discusses with the students the meaning of possible deviations. **2.** Teacher/facilitator coordinates and encourages the groups of students.	directing etc.
Phase 6: **COMMUNICATE:** students communicate and justify explanation	Communication of *possibilities*, ideas and justifications through *dialogue* with other students, with science educators, and with professional scientists offer students the chance to test their new thinking and experience and be *immersed* in a key part of the scientific process. Such communication is crucial to an *ethical* approach to working scientifically.	**1.** Students teams communicate the new knowledge they acquired, by performing their science stories in form of short plays in front of the audience.	**1.** Teacher/facilitator organizes and supports the final performance of the students.	Finalization and Rehearsals of students' short plays

Phase 7: **REFLECT:** students reflect on the inquiry process and their learning	*Individual, collaborative and community-based* reflective *activity for change* both consolidates learning and enables students and teachers to balance educational tensions such as that between open-ended inquiry learning and the curriculum and assessment requirements of education.	**1.** Students discuss with each other and with the teachers/facilitators of the summer school about the main characteristics of their work both in science and art/creativity field. What was successful, what wasn't so. **2.** Students performance is also evaluated by those who watch their short plays (scientists, teachers, I artists, science communicator experts, even general public).. **3.** Students can compare their views regarding the science concepts they dealt with before and after the summer school they participate in	**1.** Teachers/ facilitators discuss with the students what went well and what did not concerning the summer course Evaluate whether all students were involved in the creative inquiry process 2. Teachers/ facilitators take part in the evaluation process.	

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		and think which parts of the summer course influenced them the most.		

6 Additional Information

As an example of a summer school program, the agenda of CREATIONS summer school at Messini is given.

Messini Summer School Agenda					
	Thursday **July 28th**	**Friday** **July 29th**	**Saturday** **July 30th**	**Sunday** **July 31st**	**Monday** **August 1st**
08:00-09:00		**Breakfast**	**Breakfast**	**Breakfast**	**Breakfast**
	Students' arrival	**09.00-10.00** **The experiment of the century in a school lab** *Cristina Kourkoumelis* *University of Athens* **10.00-11.00** **Virtual visit to ATLAS Experiment at CERN** *Ioannis Gialas* *University of the Aegean* **11.00-12.30** **Laboratory exercise** *Cristina Kourkoumelis*	**10.00-11.30** **Detecting Gravitational Waves** *Manolis Chaniotakis* *Ellinogermaniki Agogi* **11.30-13.00** **Make yor** **Create your own science story** *Spiros Kitsinelis* *Menelaos Sotiriou* *Zacharoula Smyrnaiou* *University of Athens*	**9.30-10.30** **Higgs particle: Past,** **Present and Future** *Michalis Karatzinos* *CERN* 10.30-13.00 Simulating Robotics using Scratch– Communication Protocols *Georgios Papadopoulos* *Ellinogermaniki Agogi*	**10.00-11.00** Creativity: Learning Science through Art *Spiros Kitsinelis* *Menelaos Sotiriou* *Science View* **11.00-13.00** Students' presentations

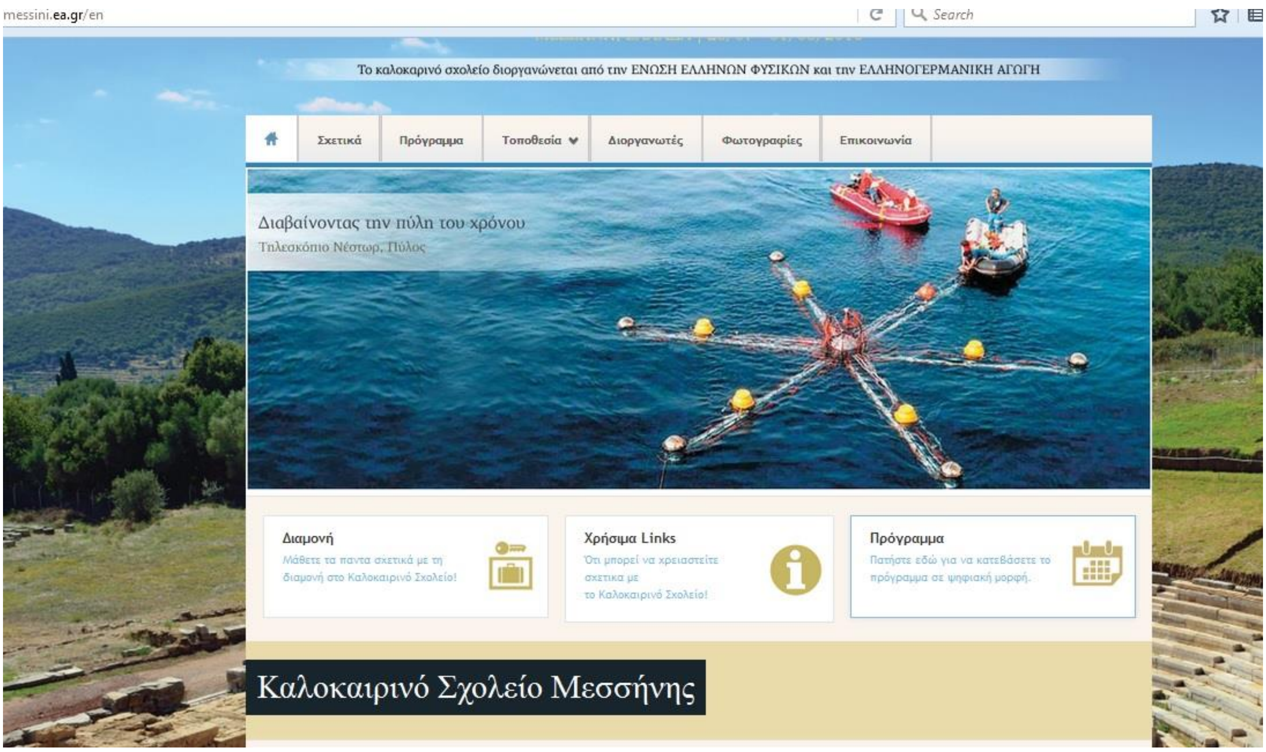
		Georgios Vasiliadis *University of Athens*			
13:00-14:00	**Lunch**	**Departure to Pylos**	**Lunch**	**Lunch**	Students' departure
	17.00-17.30 **"This small, this Great World"** *Sofoklis Sotiriou* *Ellinogermaniki Agogi* **17.30-19.30** **Dialoques regarding the Microcosm and the Universe** *Sofoklis Sotiriou* *Ellinogermaniki Agogi* *Spiros Kitsinelis* *Menelaos Sotiriou* *Science View*	**13.30-14.30** **Visit to NESTOR Research Instute (Presentation)** *Sofoklis Sotiriou* *Ellinogermaniki Agogi*	Free Time	**15:00-17:00** Automatic control using scratch *Georgios Papadopoulos* *Ellinogermaniki Agogi* **17.00-18.00** **Create your own science story** *Spiros Kitsinelis* *Menelaos Sotiriou* *Zacharoula Smyrnaiou* *University of Athens*	

		Swimming-Lunch **(Methoni)**			
		Free Time	**19.00-23.00** **Visit to the traditional village of Vanada, Messinia. – Science Café** *Sofoklis Sotiriou* *Ellinogermaniki agogi* *Spiros Kitsinelis* *Science View*	**Free Time**	
20:00-21:00	**Dinner**	**Dinner**	**Dinner**	**Dinner**	

Table1. Agenda of CREATIONS summer school at Messini

Link to official website of CREATIONS Summer school at Messini:

http://messini.ea.gr/



Picture 1. Snapshot of Summer school's official site Homepage

7 Assessment

The methodological tool of content analysis was used to analyze the data collected from the observation of the dramatized scenarios and to connect them to the characteristics of Embodied Learning. Based on the theoretical framework presented in brief below there has been developed a system of categorizing the ways which students through Embodied Learning: a) represent scientific content/generate meaning, b) communicate with one another, c) entertain the audience while they dramatize scientific scenarios which take into account both the teaching of sciences and theatre techniques.

Embodied Learning constitutes a contemporary pedagogical theory of learning, which emphasizes the use of the body in the educational practice and the student-teacher interaction both inside and outside the classroom and in digital environments as well. Using the body is essential in concept representation and communication while this is also confirmed by the emphasis other fields and cognitive objects place on the body as a learning tool, such as dance theatre, kinesiology, athletics even Mathematics and Physics. All these cognitive objects have student collaboration, movement and the process of cognitive development as a common denominator.

Traditionally the body has not been used in education. Every involvement of the body had been consistently excluded from the educational practice, the process of learning and the interaction among students. The notion of Embodied Learning was not known and therefore not acceptable by the educational community such as the teachers and the students. Consequently it was difficult to understand that the body does not solely constitute a means of knowledge, or a mediator, but it also reflects the student's interaction with the environment.

Embodied Learning is closely related to constructivist models and to modern educational theories regarding the role of the teacher, of the student and of learning itself in the educational practice. Embodied Education has been defined as the basic concept which includes Embodied Teaching and Embodied Learning [1]. In fact, the terms Embodied Learning and Embodied Teaching are used alternately to refer to new scientific and educational practices [2].

In accordance with the constructivist principles, the body is used both inside and outside classroom for experiential learning and is not treated as a place of learning. The principles of Embodied Learning provide answers to questions related to the ways knowledge is constructed by students as they leave behind them the academic model of perceiving knowledge and treat each student as a whole, while they view everyone's body as a tool for knowledge construction and as a knowledge carrier [3],

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[4], [5], [6], [7]. Language and full-body motion have been studied as an integral means through which students express thoughts and meanings when they interact with a set of collaborative digital games designed by the researchers [8] in creative and innovative teaching approaches [9]. This way, each student is placed in the center of the educational process, while disinterestedness is transformed into active participation and emotional neutrality into cooperation.

In Embodied Learning, new knowledge is affected by the conditions it is used and by the types of activities the student is expected to participate in. Consequently, the following parameters should be taken into consideration when designing an activity:

a) cognitive involvement to the topic, cognitive processes, representation of a scientific notion
b) body movements
c) expression of the student's feelings
d) clarity of instructions
e) holistic design of activities
f) student cooperation
g) ability of students to apply acquired knowledge to new environments

It becomes evident that Embodied Learning is in accordance with new educational practices, as it uses personality as a whole, and promotes the way students learn and not the content of learning in the learning process. However, only few studies have been conducted to link Embodied Learning to the dramatization of educational theatrical scenarios and to the representation of scientific concepts and knowledge, with the aim of developing student creativity and critical thinking, their active participation to the learning process, their deep understanding of scientific notions and phenomena and the interdisciplinary connection of Sciences to forms of Art.

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8 Possible Extension

The flexibility which characterise the curriculum of a Summer school course, give us the choice to adopt educational activities from a variety of different CREATIONS demonstrators according to the general educational scenario and the chosen learning objectives of the course. For instance, Science&Art@School workshops, Student Parliament, Global Science Opera and GSOrt (and a lot more) are demonstrators which could be merged and produce a number of different appealing for the students new demonstrators. Furthermore by motivating students from more than one country to participate in a summer school course like this, that could lead to a large scale international activity, where students from different countries get in touch, communicate and share their ideas, regarding science and arts.

9 References

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