

D3.1.x Particle Physics Masterclass

Project H2020-SEAC-2014-
Reference: 2015/H2020-SEAC-2014-1 ,
665917
Code: D 3.1.x
Version & Version 1 26/05/2016
Date:

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Introduction / Instructions

This part should be excluded from your FINAL Demonstrator

1. Summary of the CREATIONS approach

As a result the CREATIONS approach is informed and grounded on three closely interrelated aspects: a) the CREATIONS features, b) the RRI principles and c) the IBSE principles.

CREATIONS Pedagogical Framework		IBSE	
CREATIONS features	RRI aspects	Essential features of IBSE	Effective learning environments
• Dialogue • Interdisciplinarity • Individual, collaborative and communal activities for change • Balance and navigation • Empowerment and agency • Risk, immersion and play • Possibilities • Ethics and trusteeship	• Governance • Public • Science education engagement • Gender equality • • Open access/open science • Ethics • Sustainability • Social justice/inclusion	➤ QUESTION ➤ EVIDENCE ➤ ANALYSE ➤ EXPLAIN ➤ CONNECT ➤ COMMUNICATE ➤ REFLECT	• Communities of practice • Simulations • Arts-based • Dialogic Space / argumentation • Experimentation (Science laboratories and eScience applications) • Visits to research centres (virtual/physical) • Communication of scientific ideas to audience

Although the key aspects of the CREATIONS approach are presented in a tabular format, the process is in practice highly organic, enabling the dialogue among students, teachers, researchers, ICT media and creative representation, drawing on a range of personal and disciplinary knowledge to thread across and between these features

2. The Demonstrators' Generic Framework

The design of **Demonstrators' Generic Framework** is mainly based on IBSE Best Practice of Pathway (Summer school, 2013), Scenario of Metafora EU project (e.g. 3d juggler (Smyrniou et al., 2012a; 2012b)) and Implementation Scenario of CREAT-IT EU project (such as Science Theatre Implementation Scenario, M. Sotiriou, 2015).

There are different ways to approach inquiry. Reflective inquiry seeks to draw attention on the coupling of metacognition and inquiry in the context of solving open-ended, ill-structured investigations in science (Kyza & Edelson, 2003). The Shimoda et al (2002)'s generic inquiry cycle is made explicit to students and is presented as a sequence of goals to be pursued. The Bruce & Bishop (2002) circle aims for students to learn how to learn and metacognitive skills, and stresses the need to engage children as active learners to collaborate and to understand the perspectives of others. Schwartz et al (1999) circle is implemented as a technology template to guide learners through case-, problem-, project-based learning. Although many versions of the inquiry cycle have been presented by various authors (de jong et al., 2002;

Pedaste et al., 2015), the IBSE Best Practice of Pathway cycle was chosen as the most suitable for Creations. Besides this core cycle, there is a place for Question, Evidence, Analyse, Explain, Connect, Communicate and Reflect (figure 1). This circle stresses the need to engage children as little scientists, creative learners and science communicators.

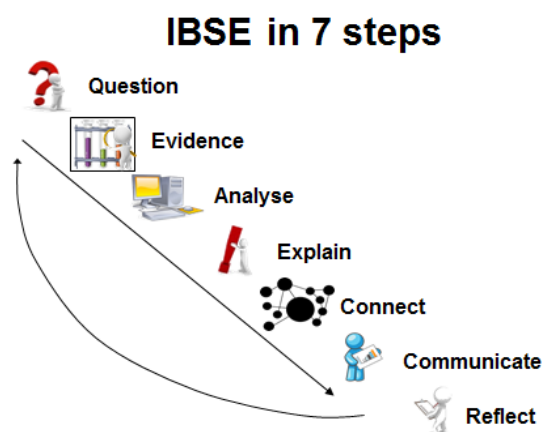


Figure 1: IBSE Best Practice of Pathway, Summer School, (Rosi, 2013)

The Demonstrators’ Generic Framework structures the description of the pedagogical intervention around what we called “Introduction” or “Demonstrator Identity” which includes information about the : author, subject domain, type of activity, duration, setting and effective learning environment. The second element of the structure is the “Rationale of the Activity/ Educational Approach” which focuses on: the teaching and learning problem (challenge) addressed by this demonstrator and the added value of using the Creation Project for implementing this demonstrator. Challenge-based learning builds on the successes of problem-based learning models where students engage in self-directed work scenarios (or “problems”) based in real life (Johnson, Laurence et al., 2009). By giving students the opportunity to focus on a challenge of global significance, challenge-based learning creates a space where students can direct their own research into real-world matters and think critically about how to apply what they learn (Smyrniou, et al., 2015; Johnson, Laurence et al., 2009). An example could be an art & science event (performance, paintings, etc.).

The third element of the structure involves the learning objectives which are divided to two categories which involve domain specific learning and general learning skills which is supported by the Creation Framework. The fourth element of the Demonstrators’ Generic Framework involves the “Demonstrator characteristics and Needs of Students” and aims at collecting information about the issues explored and the real needs of students. It is very important because the literature of Science Education offers important data concerning the students’ attitudes towards science and underlines the continuing decline of interest the

young people show in pursuing scientific careers (S&M) in a way that threatens the future of Europe (ROSE, Osborne et al., 2003; Osborne & Dillon, 2008).

The fifth element provides information about the Sequence and description of the activities focusing on a detailed description of each activity and the effective learning environment (s) involved and the sixth additional information. Finally, some assessment suggestions are requested along with possible extensions and list of suggested sources/references. For example, inter-workgroup assessment: after performing a theatrical stage on / represents a scientific concept or cultural elements, the workgroups may exchange their ideas / performances/ representations and ask their peers to evaluate them. The criteria for the evaluation may be set collaboratively by the workgroups as they discuss in class /stage, etc.. Concerning the possible extensions, after having performed a theatrical stage on scientific concept or cultural elements putting into effect their own ideas, the students share their performance and ask the students of another team to perform on the same scientific concepts (or cultural elements). At this phase of the performance, the workgroups decide on the representation of scientific concept (or cultural elements) through embodiment (gestures, facial expressions, full body movements, sentiments), music, choreography, narration, or using digital tools or other objects.

1 Introduction / Demonstrator Identity

1.1 Subject Domain

Particle Physics

1.2 Type of Activity

School, university or research facility based – Masterclass held at national laboratory

1.3 Duration

1 day (the programme of the day is modular, and different components can be run independently)

1.4 Setting (formal / informal learning)

Both formal and informal settings - formal lectures, informal tours in small groups, workshop activity in teams, opportunities for questions throughout.

1.5 Effective Learning Environment

Simulations aiming to enable the visualization of theoretical models and facilitate inquiry-based experimentation

- Students and teachers will take part in computer workshops, using MINERVA visualization and analysis package.

Dialogic space / argumentation aiming to engage students in argumentation and dialogic processes for a better insight into the nature of scientific enquiry and the ways in which scientists work

- Students and teachers are encouraged to question and interact with scientists and engineers during the workshop, tour and informal lunch session.

Experimentation (Science laboratories and eScience applications) aiming to enhance students' physical and intellectual interaction with instructional materials through 'hands-on' experimentation and 'minds-on' reflection.

- Students and teachers will use real LHC data in order to discover properties of the Higgs Boson.

Visits to research centres (virtual/physical) aiming to connect the science classroom with research infrastructures, addressing the enhancement of informal learning settings.

- Students and teachers will all have a guided tour around a particle accelerator, with a scientist or engineer working there.

Communication of scientific ideas to audience addressing the need to establish settings in which learners will be enhanced to externalize and elaborate on scientific concepts they have acquired while interacting with an audience (learners, teachers,

scientists, parents, etc.); promoting this way a dual channel of communication: a) reflective processes (self-engagement for scientific consistency and verification) and b) explicit elaboration of scientific ideas through interaction and 'extroversion'.

- Students and teachers will have a series of lectures and take part in an interactive quiz.

2 Rationale of the Activity / Educational Approach

2.1 Challenge

Particle physics and the work of the Large Hadron Collider are very inspirational topics and students are curious about the ongoing research. Often, though, teachers do not feel they have the knowledge and background to be able to answer their students' questions. The particle physics masterclass allows students, and teachers, to interact with the scientists and engineers working at the Large Hadron Collider, and gives them the opportunity to experience particle physics for themselves.

2.2 Added Value

The collaborative computer workshops use the MINERVA tool, which has been developed to help students learn more about the ATLAS experiment and particle physics at CERN. It is based on Atlantis, the event display used at ATLAS to visualise what happens in the detector. The aim of MINERVA is to give students a better understanding of how particle detectors work and the physics that they study. Currently, in MINERVA, students are able to study W and Z boson events by observing their decay products and apply this knowledge to search for the Higgs boson. By taking an inquiry based approach to finding the Higgs, this workshop enables students to experience what it is like to be a particle physics researcher.

The masterclasses give students the opportunity to interact with scientists and engineers in both formal and informal settings. During the tours and workshops students are in small groups and have the chance to question their guides and demonstrators.

Throughout the masterclass there are opportunities for the students and teachers to question the particle physicists working at CERN: both on the curriculum material and on further questions.

By giving students the opportunity to visit some of the UK's particle accelerators, they will experience for themselves the size and scale of these facilities, learn more about the real-world impact of particle physics and accelerator research, and appreciate the fact that these facilities exist in the UK as well as at CERN.

The content of the masterclass is designed to link very closely to the English school curriculum in the final two years of school (age 16-18). This gives students and teachers more confidence to address and study these inspiring topics.

3 Learning Objectives

3.1 Domain specific objectives

The main aim of the Particle Physics Masterclasses is to **inspire students with the cutting-edge and popular subject of particle physics.**

The domain specific objectives of the Particle Physics Masterclass are:

- Give students and teachers the chance to interact with particle physicists working with and at CERN
- Give students and teachers the chance to visit a large-scale particle accelerator in the UK (the ISIS Neutron and Muon Source, or Diamond Light Source), learning about the applications of particle physics
- Give students and teachers first-hand experience of ‘big science’ and allow them to appreciate both the scale of engineering involved and other applications of accelerator science
- Give students and teachers access to LHC data so that, working collaboratively within a group, they can discover the Higgs for themselves
- Assist teachers to build confidence in teaching relevant subjects

3.2 General skills objectives

The general skills objectives for the Particle Physics Masterclass are:

- Develop an understanding of scientific inquiry and careers
- Highlight the achievements of science and technology
- Understand the methodology that guides scientific investigation
- Value science and technology for its economic, social and cultural contribution to society

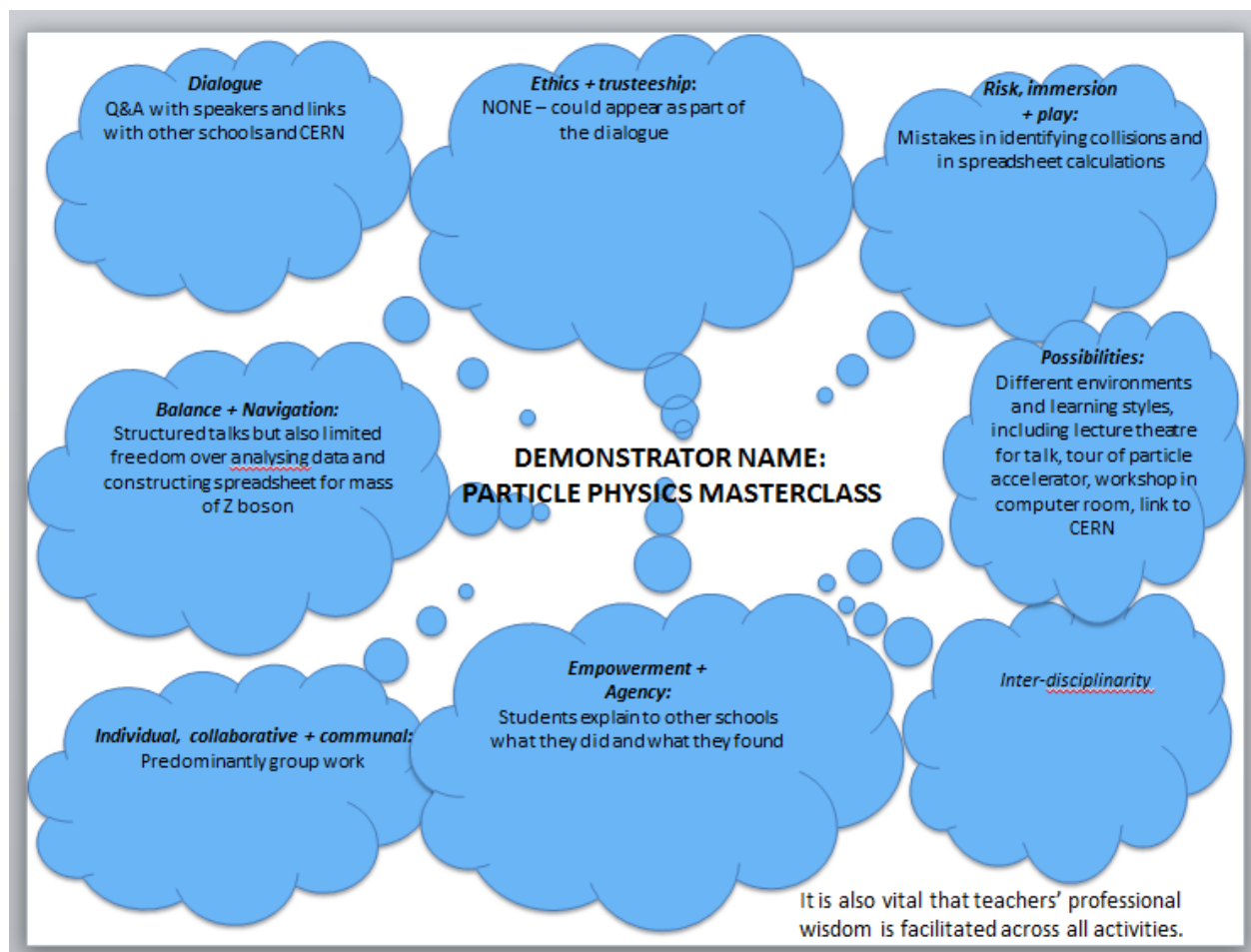
4 Demonstrator characteristics and Needs of Students

4.1 Aim of the demonstrator

The demonstrators main aim is to engage 16-18 year old high school students studying physics and science teachers with particle physics through:

- Lectures and discussions with scientists and engineers (A very brief guide to accelerators, Fundamentals of particle physics, The Large Hadron Collider, Applications of accelerators)
- Hands on computer workshop using LHC data and the MINERVA tool
- Tour of particle accelerator in a small group
- Interactive quiz

The masterclass improves the knowledge and confidence of both students and teachers in particle physics.



4.2 Student needs addressed

- Particle physics is a topic that interests and inspires, but which some teachers are not confident teaching.

- Using IBSE for the masterclass, allowing students to use real LHC data for themselves, acts to dispel the notion that 'particle physics isn't for me'.
- Gives students and teachers access to experts in what is considered to be a complicated field.
- Students are able to see how the direct applications of particle physics affect their lives.

5 Learning Activities & Effective Learning Environments

Science topic: Particle Physics

(Relevance to national curriculum)
Key component of A level syllabus (UK students, age 16-18)

Class information

Year Group: Year 12 & 13 (sixth form)

Age range: 16-18

Sex: both

Pupil Ability: Mixed (The scenario allows space for pupils of various abilities to participate)

Materials and Resources

What do you need? (eg. printed questionnaires, teleconference, etc.) Lecture facilities, computers with internet access, evaluation questionnaires.

Where will the learning take place? On site or off site? In several spaces? (e.g. science laboratory, drama space etc), or one? Masterclasses will be held at your local particle physics group. Some of the activities can be adapted for the classroom.

Health and Safety implications? Knowledge of local fire and radiation procedures.

Technology? Computer and internet access. Voting pads (for the quiz).

Teacher support? Reference material.

Prior pupil knowledge

- Basic ICT skills
- Commitment to attend the full day's event

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

During this scenario, students will:

Lectures: Learn about: the principles and applications of particle accelerators, fundamentals of the standard model, large hadron collider.

Tour: Experience a real particle accelerator. Appreciation of the real world applications of particle physics – in engineering, chemistry and the life sciences as well as physics.

Workshop: Empowerment from using real LHC data to solve a challenge and appreciation of collaborative nature of scientific research.

Assessment

Quiz to test their scientific knowledge and understanding.

Student questionnaire.

Teacher e-survey

Differentiation

How can the activities be adapted to the needs of individual pupils?

All the students do the same activities, there are opportunities for students to ask questions and clarify points throughout the day.

Key Concepts and Terminology

Science terminology:

Maths, Particle and Accelerator physics.

Arts terminology:

Session Objectives:

During this scenario, students will deepen their understanding of particle physics concepts and phenomena, through both formal and informal sessions.

Masterclasses encompass the CREATIONS features of creativity: including dialogue; risk, immersion and play; possibilities; empowerment and agency; individual, collaborative and communal; balance and navigation.

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

Students will engage with lecturers, tour guides and workshop leaders, creating a dialogue

Teachers will engage along with their students

6 Additional Information

Further information can be found at:

<http://atlas-minerva.web.cern.ch/atlas-minerva/>

<http://www.stfc.ac.uk/public-engagement/for-schools/schools-rutherford-appleton-laboratory/#ppm>

<http://physicsmasterclasses.org/>

<http://www.stfc.ac.uk/public-engagement/for-schools/particle-physics-for-you/particle-physics-masterclass-programme/>

7 Assessment

- Students and teachers will undertake an interactive quiz to gauge their learning from the masterclass.
- CREATIONS evaluation (student and teacher questionnaire) will be used to evaluate the masterclass.

8 Possible Extension

Students will be encouraged to explore the LHC for themselves by visiting

<https://www.higgshunters.org/>

so that they can become involved in further analysing LHC data, as part of the citizen science project.

Teachers can engage in further projects, such as:

- CERN@school
 - A project that brings technology from CERN into the classroom, allowing students to design and analyse their own experiments
 - <https://cernatschool.web.cern.ch/>
- HiSPARC
 - HiSPARC is a project in which secondary schools and academic institutions join forces and form a network to measure cosmic rays with extremely high energy.
 - <http://www.birmingham.ac.uk/schools/physics/outreach/HiSPARCproject.aspx>

These projects will allow teachers and their students to continue engaging with particle physics in an empowering, IBSE-based manner.

9 References

Further information can be found at:

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