D3.1.x Neutrino Passoire

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D3.1 CREATIONS Demonstrators

Table of Contents

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D3.1 CREATIONS Demonstrators

D3.1 CREATIONS Demonstrators

1. Introduction / Demonstrator Identity

1.1. Subject Domain

Particle Physics

1.2. Type of Activity

Session 1: School based workshop
Session 2: Theatre, festivals, performance venue

1.3. Duration

Session 1: 2h to 1/2 day
Session 2: 1 hour 30 min (+1 hour 30min for the preparation of the performance)

1.4. Setting (formal / informal learning)

Session 1:

- Starting formal: introductory talk in classroom
- Continuing informal: group work in classroom

Session 2:

- Informal learning, at a theatre or festival venue. The performance is introduced with a short (5') historical review of the topic, while a 35'-40' minutes Q&A session follows the performance.

1.5. Effective Learning Environment

- Arts-based: the discovery of the properties of the particles through dance is a creative approach to learning (Session 1). Watching a science-inspired performance and in the subsequent Q&A session can be motivating and inspiring for the audience (Session 2).
- Dialogic space / argumentation: through questioning and dialog the students and/or the audience are allowed to express their views regarding scientific research and explain their choices regarding their own dance moves (Session 1) or discuss the choices of the artists (Session 2).
- Communication of scientific ideas to audience: the workshop allows for the modern

scientific ideas or particle physics to be shared with the young audiences (ages 8-13, Session 1), and more mature audiences (ages 16+, Session 2)

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- Communities of practice: school community works together during the workshop. After the workshop, schools will be invited to finalise and present the improvised performance, potentially involving parents as audience.

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2. Rational of the Activity / Educational Approach

2.1. Challenge

Students and young people hear on the news about the recent discoveries in the area of particle physics and this creates curiosity about the subject and a series of questions on the world of particles.

This demonstrator addresses the identified need to bridge the gap between the latest scientific breakthroughs and the public of, effectively all ages, in an easy and accessible way. This will satisfy and feed their curiosity at an early stage with the hope it will be sustained in future years.

2.2. Added Value

Session 1: The topic of particle physics is introduced via the curriculum only at the last two years of school study in the UK (ages 17-18). Younger audiences are equally curious about what matter is made of. Students learn modern concepts of particle physics and how particle physicists work to reveal the hidden structure of nature. This enhances their understanding of

- How science works
- How the particles change from one another, somewhat like changing personalities.
- How particle physicists "see" the seemingly invisible

It also allows them to experience science in a fun and less daunting way. Students have the possibility of interacting with scientists and performers at all time throughout the workshop.

Session 2: The topic of particle physics comes repeatedly at the news, and even more mature students or young adults have many questions about what this is all about. The audience has the possibility of interacting with scientists through an open questions session after the performance, and obtain responses to all possible questions they may have.

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3. Learning Objectives

3.1. Domain specific objectives

The main objectives of the workshop are:

- That matter is made up of elementary particles which are structured into larger particles, for example protons, neutrons and eventually atoms
- To understand that we cannot see the elementary particles, but particle physicists have invented ways of detecting them
- To learn about the Large Hadron Collider (LHC) at CERN as a "motorway" where particles are accelerated to reach very high speeds
- To learn that through such experiments physicists found out 3 families of particles and the corresponding antimatter ones
- To appreciate some of the characteristics and properties of the elementary particles, and understand that these "seemingly" mysterious behaviours have been studied in detail by scientists.
- To have some idea of how particles interact to create new particles.

3.2. General skills objectives

- Break stereotypes (Session 1 & 2) on how scientists look and behave
- Demystify science and scientists (Session 1 & 2)
- Bridge the gap between students and the public, in general, and scientists (Session 1 & 2)
- Open a channel for dialogue students/public-scientists (Session 1 & 2)
- Interdisciplinary: between science and arts (Session 1 & 2)
- Communication skills (Session 1)
- To use creative and more familiar skills e.g. dancing, playing games to help access science ideas (Session 1)
- To work with other students who they do not necessarily know, to reach a common target (Session 1), i.e. team building, which reflects how scientists work today.

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4. Demonstrator characteristics and Needs of Students

4.1. Aim of the demonstrator

To explain recent developments in science, and in particular the mysterious world of neutrinos, using performing arts and dance. This way science is presented in a more attractive way to students and the audience. The Q&A session aims to create an open channel of discussion student/public-scientist. Students learn by IBSE model to explain science in their own way. Furthermore, the demonstrator aim to satisfy the curiosity of younger students, and show them that asking questions is an important part of science investigation.

4.2. Student needs addressed

- Learn science in a more attractive way (Session 1 & 2)
- Satisfy curiosity (Session 1 & 2)
- Role model, students see a real scientist (Session 1 & 2)
- Possibility to express their worries and questions about science career, scientists and also developments in science. (mostly Session 2)
- Capacity to communicate science (Session 1)
- Game playing and interaction with others (adults, specialists, other students) (Session 1)
- Engaging in fun group activities that has a clear educational purpose (Session 1)
- Freedom of expression to choose their preferred way of dancing (Session 1)

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5. Learning Activities & Effective Learning Environments

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Science topic: Particle Physics (Relevance to national curriculum) Session 1: Not in the curriculum for these ages. Session 2: Class information Year Group: Session 1: 4- Part B: high school, undergraduate, and graduate students in university Age range: Session 1: 8-13 Session 2: 16+ Sex: both Pupil Ability: all inclusive	Materials and Resources *What do you need? (eg.*printed questionnaires, teleconference, etc.) Session 1: • Introductory power point presentation on particle physics • Sculpture-Clothe CLOC • Teacher guidelines • Light, plastics colanders • Pens and coloured papers Session 2: Stage: • Minimum dimensions: 6mx7m • A wall for projection Music: • AER 60-3 Acoustic Guitar Combo Amplifier (60 Watts, 1x8") Video: • A video-projector within human-height reach Lights: • Possibility to eliminate day light for the projection Props on stage • Sculpture-Clothe CLOC • 3 colanders Where will the learning take place? Session 1: School Session 2: Theatre/festival Health and Safety implications? None Technology? As detailed above. Teacher support? Yes. Student encouragement as necessary
Prior pupil knowledge: none	

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Individual session project objectives:

The students by the end of Session 1, should be able to appreciate that the various particles have different properties, and that they can change from one to another either via interactions or through more subtle quantum effects. Furthermore, they will appreciate the many different scales involved, the elementary tiny neutrinos, to the earth, to the sun, to the universe. That things are not what they seem and others are not visible at all: solid masses are constantly penetrated by much smaller ones; our eyes are not the only witnesses of the world; that however far the neutrinos are from the human condition, we can still try to interpret them and to be inspired by them. Their curiosity to explore the mysterious world of particles should be boosted, and through the questions and answer to the physicists should be guided to further exploration.

The audience by the end of Session 2, should be able to appreciate the subtleties of the microcosm, and how particles interact or change from one to another. The subsequent Q&A session here is even more important, not only to support their inquiries/curiosity, but also to correct any possible misconceptions.

Assessment	**Differentiation**	**Key Concepts and Terminology**
Questioning and dialog through both sessions	In Session 1 students have freedom of choice regarding their expression through dance. In Session 2 the individuals from the audience have freedom to ask any question they may have during the Q&A session	**Science terminology:** Particle physics, neutrinos, quarks, leptons, bosons, matter, antimatter, Higgs boson, photons, mass, Big Bang, the Sun, Oscillations of Neutrinos **Arts terminology:** dance, performance, improvisation, choreography

Session Objectives:

During this scenario, students will deepen their understanding of scientific concepts using their creativity, imagination and freedom of expression.

Learning activities in terms of CREATIONS Approach

IBSE Activity	**Interaction with CREATIONs Features**	**Student**	**Teacher**	**Potential arts activit**

				y
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.	Session1: Engage with teacher's questions. Watch power point presentation Session 2: Follow short introduction. Watch dance performance .	Eg. Will use challenging questions and the web (images, videos) to attract the students' interest in particle physics.	Session 1: Interact with dance performers Session 2: Watch dance performance
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.	Students compare their ideas to existing evidence.	Guide students to relevant evidence	Comparing artistic ideas to other art-works, especially school art works created by pupils. Give preference to art projects inspired by scientific phenomena.

Phase 3: **ANALYSE:** students analyse evidence	Students analyse evidence, using dialogue with each other and the teacher to support their developing understanding.	N/A	N/A	N/A
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.	Students improvise on dance, explaining the reasons for their choices of moves. The choreography is linked to the properties and characteristics of particles.	Workshop leader facilitates and supports as required.	Students use imagination and creativity in expressing particle properties through dance.
Phase 5: **CONNECT:** students connect explanations to scientific knowledge	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 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.	Students explore the topic using connections with familiar concepts from other disciplines (e.g. family connections)	Workshop leader facilitates and supports as required.	Creativity in making analogies and connections between dancemoves and particle characteristics

D3.1 CREATIONS Demonstrators

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.	Students present their work, after dialog and collaboration within the group, to an audience of students and teachers.	Workshop leader facilitates and supports as required.	Student dance performance
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.	Students discuss, probed by workshop leader, about the new acquired knowledge at the end of the workshop as well as to evaluate the process and learning experience.	Workshop leader evaluates through dialogue; then collects and acts on feedback.	Reflection on the process and collection of documentation.

6. Additional Information

The Neutrino Passoire is a dance performance conceived by University of Birmingham particle physicist Kostas Nikolopoulos, alongside with dancers Mairi Pardalaki and Fanny Travaglino, and musician Katerina Fotinaki. The dynamic group of artists, has already performed in prestigious venues, such the Opera of Paris and the Avignon Festival, and with renowned colleagues such as director Romeo Castellucci and singer Angélique Ionatos.

Inspired by the latest 2015 Nobel Prize in Physics, "for the discovery of neutrino oscillations, which shows that neutrinos have mass", the team started working on this elusive and omnipresent particle: The journey from its birthplace, the Sun, to the universe, while oscillating among the three flavours and traversing ordinary matter, like the Earth and our bodies.

These oscillations — where the neutrino forgets and remembers its identity — and the minimal interactions — penetrating matter with no trauma or memory of the event itself — led the artists to reconsider the image of the human body; not as an impregnable and over-sacred fortress as it is often thought of, but as a sort of a colander [(fr.) passoire], open to the outside world. This naturally led to the questioning of the notion of borders, where the team let the neutrinos give the answer.

The Neutrino Passoire was presented in March 2016 as part of the University of Birmingham Arts & Science Festival in a fully-booked auditorium, receiving overwhelmingly positive feedback. A short video teaser of the performance can be found at: https://www.youtube.com/watch?v=QmlNAHwQ4tM

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7. Assessment

Session 1: Teachers will evaluate the demonstrator using questionnaires, and will provide anonymous feedback from the classroom following the workshop.

Session 2: The audience will evaluate the performance and the subsequent Q&A sessions using questionnaires

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8. Possible Extension

The students together with their teachers and the support of the scientists and performers involved, could produce a dance performance that could be presented at the school and/or at the national science festivals.

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9. References

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