

**D3.1.1 Particle Physics Workshop**

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### 1 Introduction / Demonstrator Identity

#### 1.1 Subject Domain

Particle Physics, creative design of particles.

#### 1.2 Type of Activity

School or University based – national UK

#### 1.3 Duration

2 hours to half day

#### 1.4 Setting (formal / informal learning)

- Starting formal: introductory talk in classroom or lecture theatre (in school or at the University)
- Continuing informal: group work in classroom (in school or at the University)
- Activity's website: the work has been submitted to the Physics Education magazine of the Institute of Physics, with the title: "Particle Physics for Primary Schools – enthusing future Physicists" by Pavlidou Maria & Lazzeroni Cristina, Article reference: PED-100750

#### 1.5 Effective Learning Environment

- **Communities of practice (web-based/physical):** school community works together during the workshop; After the workshop schools can create fluffy toy-models of the particle families as a whole school project which can involve parents too.
- **Arts-based:** the design of the particles is a creative form of model making and it gives full freedom to the children to come up with their own idea of designing the particle and then making them.
- **Dialogic space / argumentation:** through questioning and dialog students are allowed to express their views regarding scientific research and explain their choices regarding their own particle design.
- **Visits to research centres (virtual/physical):** groups of students can visit the University of Birmingham and complete the workshop in the University premises. As part of this visit students will be given a tour of the campus and they will have the chance to speak to undergraduate students about university life.
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- **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).

## 2 Rational of the Activity / Educational Approach

### 2.1 Challenge

*(Description of the problem)*

Young students 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 need identified by teachers to introduce younger audiences to the world of particles in an easy and accessible way and satisfy and feed their curiosity at an early stage with the hope it will be sustained in future years.

### 2.2 Added Value

*(Elaboration of the applied creative approaches and their purpose)*

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. Moreover, the similarity between human families and human interactions and particle families and particle interactions makes the concepts easy to understand and work with. Young students learn that in the world of particles there are “likes” and “dislikes” and family groups as in the human world.

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
- The relative mass of particles
- How particle physicists “see” the seemingly invisible

It also allows them to experience science in a fun and less daunting way.

### 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 (because they are too small) but particle physicists have discovered 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 understand that particle physicists collide particles to reveal their inner structure
- 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 particles
- To have some idea of how particles interact to create new particles

#### 3.2 General skills objectives

The main objectives are:

- To use creative and more familiar skills e.g. model making, playing games to help access science ideas
- To work with other students who they do not necessarily know how to reach a common target
- To demystify scientists and science in general
- To acquire some presentation skills to communicate a physics idea

### 4 Demonstrator characteristics and Needs of Students

#### 4.1 *Aim of the demonstrator*

The main aim of the demonstrator is to use a creative way to introduce the concepts of particle physics to a younger audience, satisfy their curiosity and show them that asking questions is an important part of science investigation.

#### 4.2 *Student needs addressed*

The list includes:

- Satisfy curiosity
- Game playing and interaction with others (adults, specialists, other students)
- Engaging in fun group activities that has a clear educational purpose
- Freedom of expression to choose their preferred way of designing a particle model

**5 Learning Activities & Effective Learning Environments**



Science topic: Particle physics

(Relevance to national curriculum)

Not in the curriculum for these ages.

Class information

Year Group: 4-9

Age range: 8-13

Sex: both

Pupil Ability: e.g. (The scenario allows space for pupils of various abilities to participate) all inclusive

Materials and Resources

*What do you need? (eg. printed questionnaires, teleconference, etc.)*

- Introductory power point presentation on the world of particles
- Materials for models (plasticine, plastic balls, decorations, pipe cleaners etc.)
- Trump cards for happy families game
- Teacher guidelines
- Additional extra: Particle zoo fluffy toys

*Where will the learning take place?*

In school or at the University

*On site or off site?*

On site

*In several spaces? (e.g. science laboratory, drama space etc), or one?*

In a room that can facilitate lecture and group work

*Health and Safety implications?*

none

*Technology?*

Projector for power point presentation

*Teacher support?*

Yes. To encourage and help as necessary



Prior pupil knowledge

none

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

During this scenario, students will

**Session 1 (power point presentation with interactive demos): to introduce words, names, ideas around particle physics (1 hour)**

**Session 2 (happy families game): to familiarize themselves with the particle families (0.5 hour)**

**Session3 (particle model making): to be creative and aim to link characteristics and properties of particles with a chosen design of particle models (1 hour)**

**Session 4 (presentations): students present and explain their choices in particle model making (0.5 hour)**

Session 2 is optional depending on time constraints or can be used as a follow up activity.

Assessment

**Questioning and dialog through all sessions as well as through final session 4**

**Differentiation**

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

Students have the freedom of choice regarding

**Key Concepts and Terminology**

**Science terminology:**



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their choices in particle model making. The only restrictions link to matter anti-matter student pairs.

**Particle physics, protons, neutrons, quarks, particle accelerator, CERN, leptons, bosons, matter, antimatter**

**Arts terminology: model making**

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 activity
<p><b>Phase 1:</b></p> <p><b>QUESTION:</b> students investigate a scientifically oriented question</p>	<p>Students pose, select, or are given a scientifically oriented question to investigate. <i>Balance and navigation</i> through <i>dialogue</i> aids teachers and students in creatively navigating educational tensions, including between open and structured approaches to IBSE. Questions may arise through <i>dialogue</i> between students' scientific knowledge and the scientific knowledge of professional scientists and science educators, or through <i>dialogue</i> with different ways of knowledge inspired by <i>interdisciplinarity</i> and personal, embodied learning. <i>Ethics and trusteeship</i> is an important consideration in experimental design and collaborative work, as well as in the initial choice of question.</p>	<p>Engage with teacher's questions. Watch power point presentation and demos.</p>	<p>Workshop leader will use challenging questions pictures and demos involving the students to attract the students' interest in the structure of matter and the principles of particle physics research.</p>	<p><b>None at this stage</b></p>
<p><b>Phase 2:</b></p> <p><b>EVIDENCE:</b> students give priority to evidence</p>	<p>Students determine or are guided to evidence/data, which may come from <i>individual, collaborative and communal activity</i> such as practical work, or from sources such as data from professional scientific activity or from other contexts. <i>Risk, immersion and play</i> is crucial in <i>empowering</i> pupils to generate, question and discuss evidence.</p>	<p>Students gain an insight into the particle scattering experiment using a demo with muffin tray and balls of different sizes.</p>	<p>Workshop leader will question students to ensure links between observations and conclusions are understood.</p>	<p><b>None at this stage</b></p>



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<p><b>Phase 3:</b> <b>ANALYSE:</b> students analyse evidence</p>	<p>Students analyse evidence, using <i>dialogue</i> with each other and the teacher to support their developing understanding.</p>	<p>N/A</p>	<p>N/A</p>	<p>N/A</p>
<p><b>Phase 4:</b> <b>EXPLAIN:</b> students formulate an explanation based on evidence</p>	<p>Students use evidence they have generated and analysed to consider <i>possibilities</i> for explanations that are original to them. They use argumentation and <i>dialogue</i> to decide on the relative merits of the explanations they formulate, <i>playing</i> with ideas.</p>	<p>Students make particle models and must explain the reasons for their choices and link these to properties and characteristics of particles.</p>	<p>Workshop leader facilitates and supports as required.</p>	<p><b>Students use imagination and creativity in their design of particle model.</b></p>
<p><b>Phase 5:</b> <b>CONNECT:</b> students connect explanations to scientific knowledge</p>	<p>Students connect their explanations with scientific knowledge, using <i>different ways of thinking and knowing</i> ('knowing that', 'knowing how', and 'knowing this') to relate their ideas to both disciplinary knowledge and to <i>interdisciplinary</i> knowledge to understand the origin of their ideas and reflect on the strength of their evidence and explanations in relation to the original question.</p>	<p>Students explore the topic using connections with familiar concepts from other disciplines (e.g. family connections)</p>	<p>Workshop leader facilitates and supports as required</p>	<p><b>Creativity in making analogies and connections between model making and particle characteristics</b></p>
<p><b>Phase 6:</b> <b>COMMUNICATE:</b> students communicate and justify explanation</p>	<p>Communication of <i>possibilities</i>, ideas and justifications through <i>dialogue</i> with other students, with science educators, and with professional scientists offer students the chance to test their new thinking and experience and be <i>immersed</i> in a key part of the scientific process. Such communication is crucial to an <i>ethical</i> approach to working scientifically.</p>	<p>Students present their work, after dialog and collaboration within the group, to an audience of students and teachers.</p>	<p>Workshop leader and teacher facilitates and</p>	<p><b>Presentation and explanation of choices in model design</b></p>



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			supports as required	
<p><b>Phase 7:</b></p> <p><b>REFLECT:</b> students reflect on the inquiry process and their learning</p>	<p><i>Individual, collaborative and community-based</i> reflective <i>activity for change</i> 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.</p>	<p>Students are questioned about the new acquired knowledge at the end of the workshop as well as to evaluate the process and learning experience.</p>	<p>Workshop leader initiates the evaluation through dialog and collects and acts on feedback.</p>	<p><b>N/A</b></p>



## **6 Additional Information**

The workshop has been adapted after the input of primary and secondary school teachers and is constantly being evaluated and adapted for different student groups.

Support and training of primary and secondary school teachers will be available. However, it is understood that many primary school teachers will be reluctant to become workshop leaders due to the specialised knowledge needed for this.

There is a plan for training and CPD which will be primarily aimed at outreach science officers of universities across the UK and interested teachers.

Below you can find detailed guidelines for teachers on the tasks of the Particle Physics Workshop.

### **Particle Physics Workshop: The World of Particles and their Interactions**

#### **Task 1: Happy Families game**

##### **Resources**

One pack of 30 trump cards per group of 5 students maximum (from document "trump cards"). Each pack contains:

- 6 quarks,
- 6 anti-quarks
- 6 leptons
- 6 anti-leptons
- 6 bosons

##### **How to play** <sup>[1]</sup>



The aim of the game is to collect as many families (groups of 6 cards that belong to the same family) as possible.

1. Deal out all the cards so that every player gets an almost equal number of cards; this will depend on the number of players.
2. The dealer starts by asking another player for a card needed to complete a family.
3. If the other player has the card, they must give it to this player.
4. The player may continue asking for cards until they make a mistake.
5. When a mistake is made the player who was asked for their card takes their turn to request cards.
6. During the game, players can request and retake the cards taken from them in previous rounds.
7. When a player gathers a family they must put the 6 cards face down on the table in front of them.
8. The player who collects the most families is the winner.

### **Task 2: Make your own particle!**

#### **Resources**

To make the standard model that includes matter and antimatter:

- 30 Plastic coloured balls
  - 12 must have the same colour for quarks and anti-quarks
  - 12 must have another colour for leptons and anti-leptons
  - 6 must have a third colour for bosons
    - <http://www.theworks.co.uk/p/outdoor-toys/mega-box-of-balls/5021813115458>
    - <http://www.argos.co.uk/static/Product/partNumber/3665514.htm>
- Coloured pencils for designing the particle before making it (must include the same variety of colours as the plastic balls available)
- Black thin permanent markers (for writing on the particles)
- A box of various decorations
  - <http://www.theworks.co.uk/p/embellishments/bumper-craft-pack/5052089001978>)
- 2kg of plasticine
  - <http://www.easycomposites.co.uk/products/newplast-plasticine-modelling-clay.aspx>
- Scales to measure 5 grams



- Sellotape (to close the particle once it is stuffed)
- double-sided sellotape (to stick the features on the particle)
- Scissors and art knife for cutting the balls open
- Black and white card to be used for a feature that distinguishes matter (white) from antimatter (black)
- Top trump cards (30 in total) for designing the particles
- Worksheet "The world of particles with mass" for reference

### Designing the particles

The whole class must decide what colour balls they will assign for each particle family i.e. quarks and anti-quarks one colour, leptons and anti-leptons another and finally bosons a third colour. Each student will make one particle from a total of 30 particles.

1. Teacher distributes trump cards, one per student.
2. Students look at the box of decorations to give them an idea of what is available.
3. They read the particle information on the trump card in order to get inspiration for their design.
4. They decide what they want their particle to look like.
  - (a) For example: what will a strange particle look like?
  - (b) What will a charm particle look like?
5. Students working on a particle-antiparticle pair must sit near each other because they will be making these decisions together, since their particles will be **identical** with the exception of one feature (e.g. hat, cape, base stand) which will be made in white card for the particle and in black card for the antiparticle.
6. Students draw the particle features they chose on the trump card.

### Giving mass to the particles

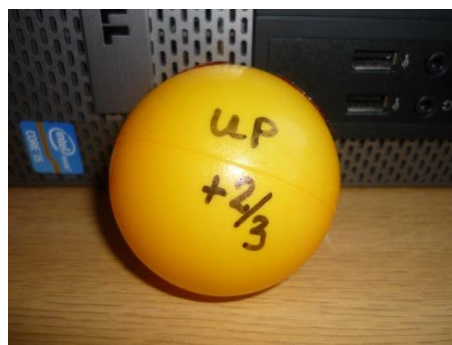
Students take one of the plastic balls (the right colour) and read the information about the mass of the particle they are making, from the worksheet "The world of particles with mass". They will add mass to their particle by filling the ball with plasticine following the rules below:

- If the particle is "very light" they do not put any plasticine in it;
- If the particle is "light", they cut-open the ball along its waist and put 5 grams of plasticine inside it. Then they close the ball and stick it with sellotape;

- If the particle is “heavy”, they cut-open the ball along its waist and half-fill it with plasticine (about 100g). Then they close the ball and stick it with sellotape;
- If the particle is “very heavy”, they cut-open the ball along its waist and fill it up entirely with plasticine (about 200g). Then they close the ball and stick it with sellotape.

### **Adding features to the particles**

1. Students look at the particle trump card and the design they chose.
2. They then take the features they have chosen from the box of decorations and use double-sided sellotape to stick these features on the ball-particle.
3. They add the final matter-antimatter feature in white or black card, which will distinguish the particle from its antiparticle.
4. Finally they write the name of the particle at its back (as seen below).



### **References**

[1] Rules for happy families game taken from <http://www.cartamundi.co.uk/en/spielregeln/gamerules/children>

### **7 Assessment**

Short term gained knowledge is assessed at the end of the workshop through questions and the student presentations.

Long term gained knowledge will be assessed through long term collaboration with specific teachers and schools.

Evaluation of the activity will also be completed using the evaluation procedures decided by the Creations project team.

### **8 Possible Extension**

The long term evaluation of the sustained knowledge has not been tested yet. This could be added on a later stage of the project as extension.

In addition, in time, it is envisaged that the workshop will be accessible to schools from a wider area of the UK via the training that will be provided to other outreach officers of other UK universities.

**9 References**

Pending article: Physics Education "Particle Physics for Primary Schools – enthusing future Physicists" by Pavlidou Maria, Lazzeroni Cristina  
Article reference: PED-100750

