Creative science|arts pedagogies for the next generation of physicists

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UNIVERSITY OF BIRMINGHAM

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European Research Council
Established by the European Commission

Reaching out to the world

- Extraordinary progress in understanding the microcosm
  - Yet, we (partially) understand only ~5% of what makes up the universe!
- Scientific progress humanity's shared intellectual achievement
  - Everyone should be given the opportunity to engage
  - Supported by public funds
- Decisions on pressing global issues
  - Informed decisions require a solid scientific base
- Today's youth is tomorrow's citizens and scientists

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The brainy image of scientists and science careers puts many young people off

Over 80 per cent of young people in our surveys agreed that 'scientists are brainy'. This association influences many young people's views of science careers as 'not for me'. Students who do not consider themselves as being among the 'brainiest' in the class are unlikely to see science careers as achievable – even if they find science interesting and attain well in the subject.

ASPIRES

Young people's science and career aspirations, age 10–14

https://www.kcl.ac.uk/ecs/research/aspires/aspires-final-report-december-2013.pdf

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Gender issues are evident from a young age. Girls are less likely than boys to aspire to science careers, even though a higher percentage of girls than boys rate science as their favourite subject. Girls are far more likely to aspire to arts-related and 'caring' careers. Among 12-13 year old students, 18 per cent of boys and 12 per cent of girls aspire to become scientists – in comparison, 64 per cent of girls aspire to careers in the arts.

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The factors which hinder students from developing science aspirations are *amplified* in the case of Black students, due to the multiple inequalities they face. This means that science aspirations are particularly precarious among these students.

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Collaborators

Ian Andrews

Mairi Pardalaki

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- Main motivations for the workshops
  - creatively embed scientific understanding
  - inspire interest in particle physics
  - stimulate a “creative curiosity” about the world
- Circumvent/break stereotypes about science, scientists, and science education
- Design informed by creative pedagogical features of CREATIONS project
  (http://creations-project.eu/ and https://sciartsedu.co.uk/)

The process

- Engage with artists through long-term collaborations
  - Grown organically out discussions, topics not predefined
- Engage the public
  - Three-way discussion: public, artists, and scientists
- Engage students, largely replicating the process followed in engaging with the artists
  - Dispel “science is ‘not for me’” view

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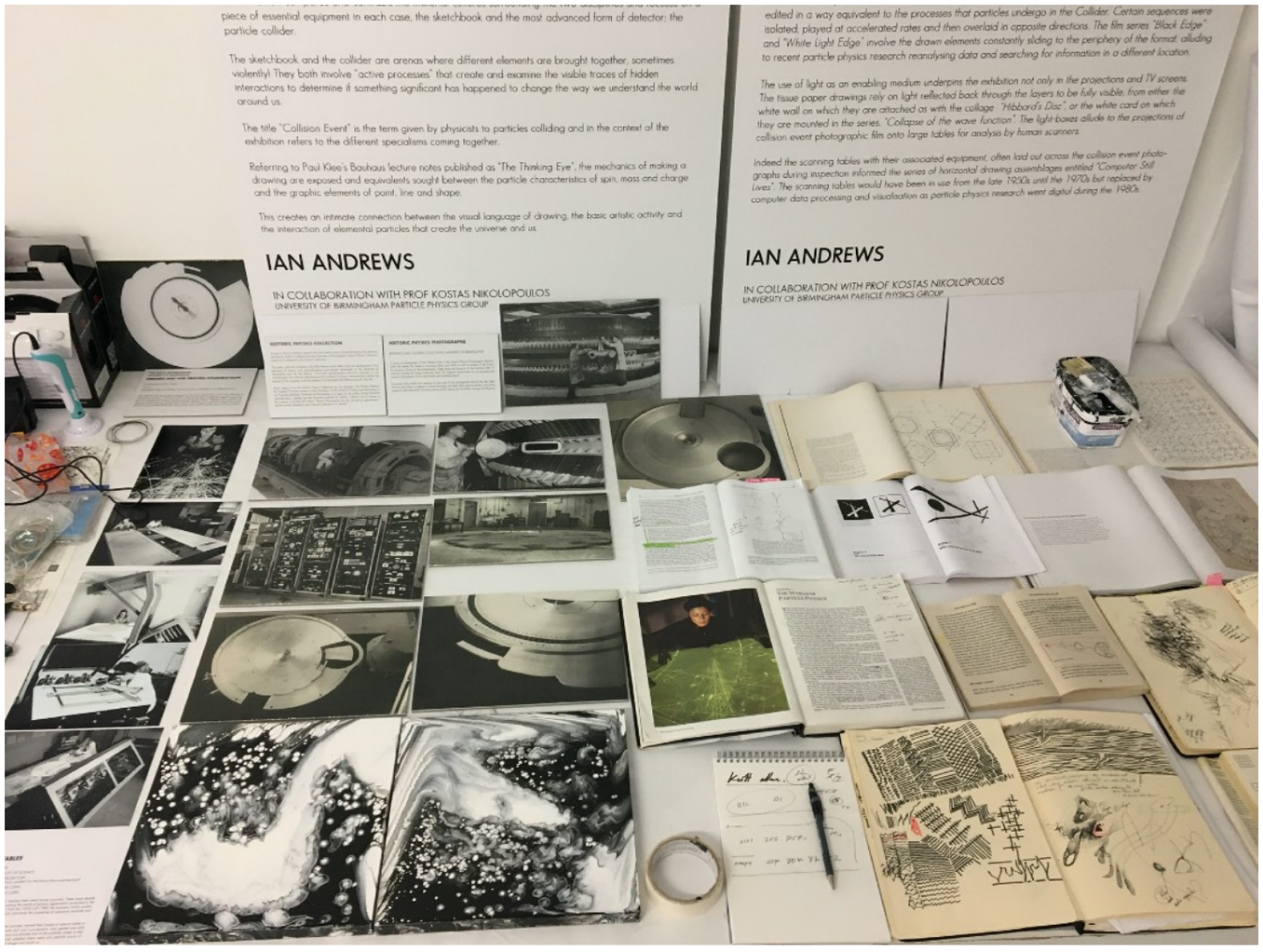

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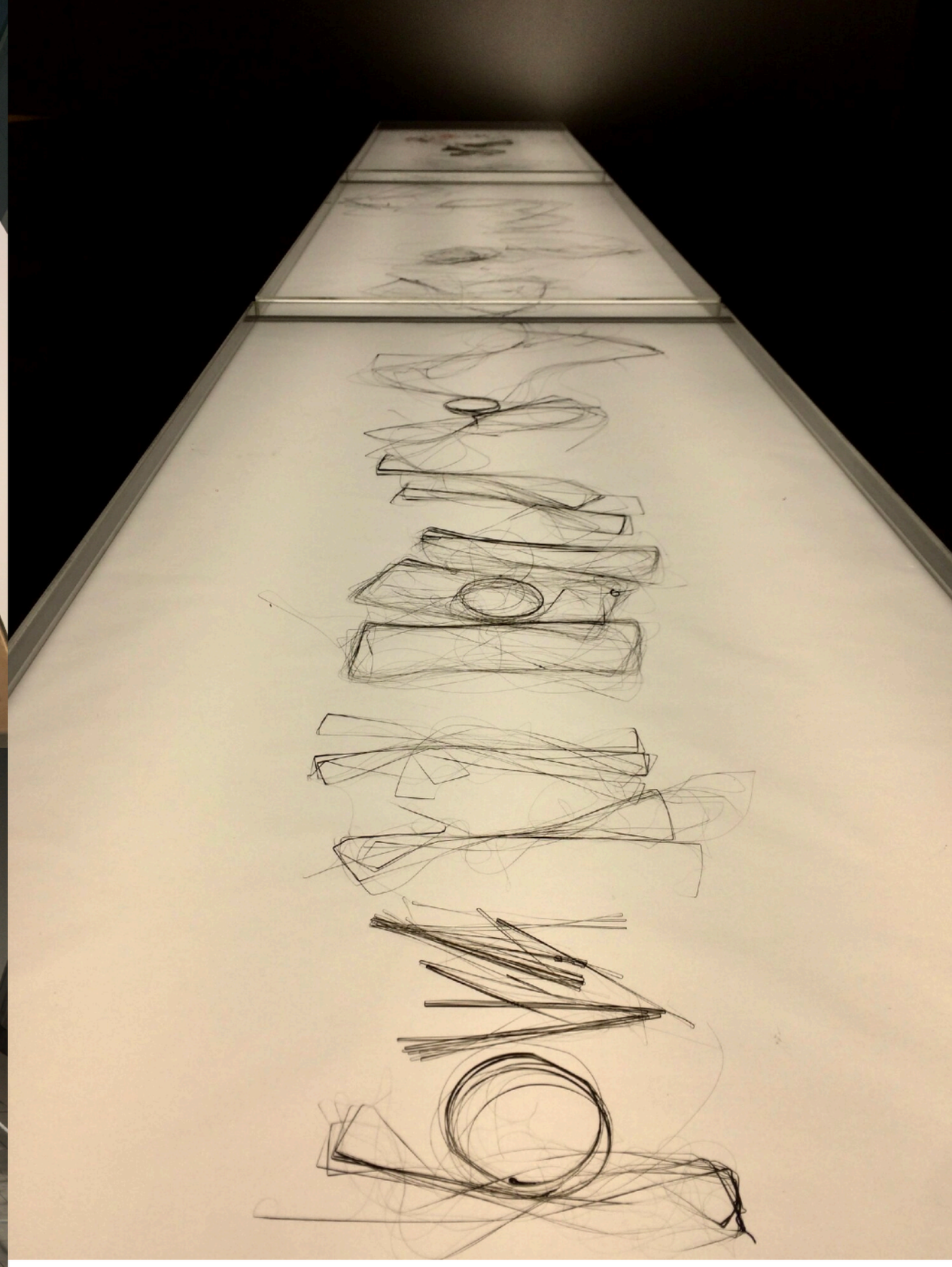
> […] it became apparent that despite obvious differences both specialisms are concerned with making the invisible, visible. Scientific developments have seen the ‘everyday’ dissolve into sub-atomic interactions only accessible by examining traces left in an enabling medium. A process mirrored by the artist expressing thoughts, emotions and insights through marks made and materials manipulated.

https://www.thesketchbookandthecollider.com/



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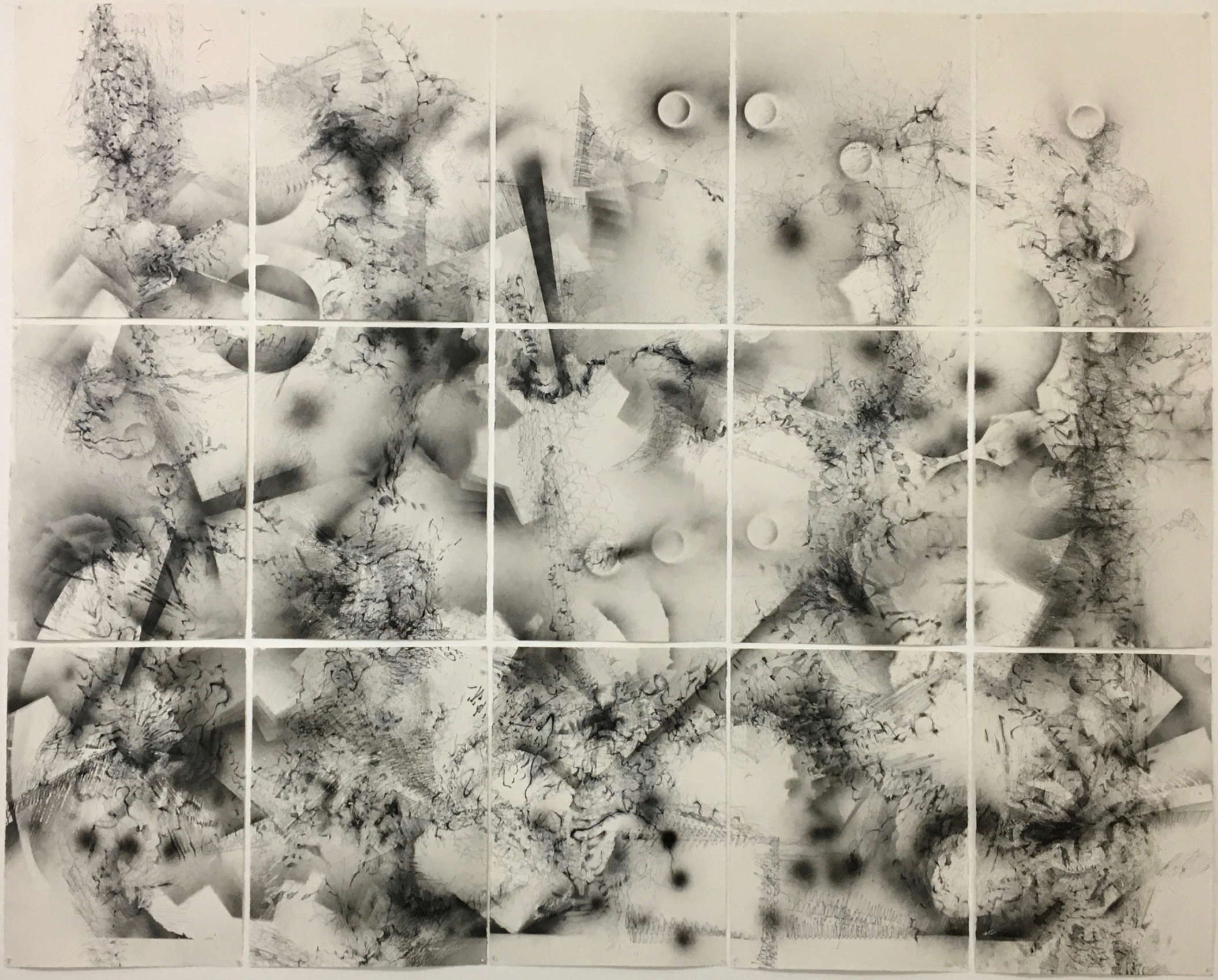

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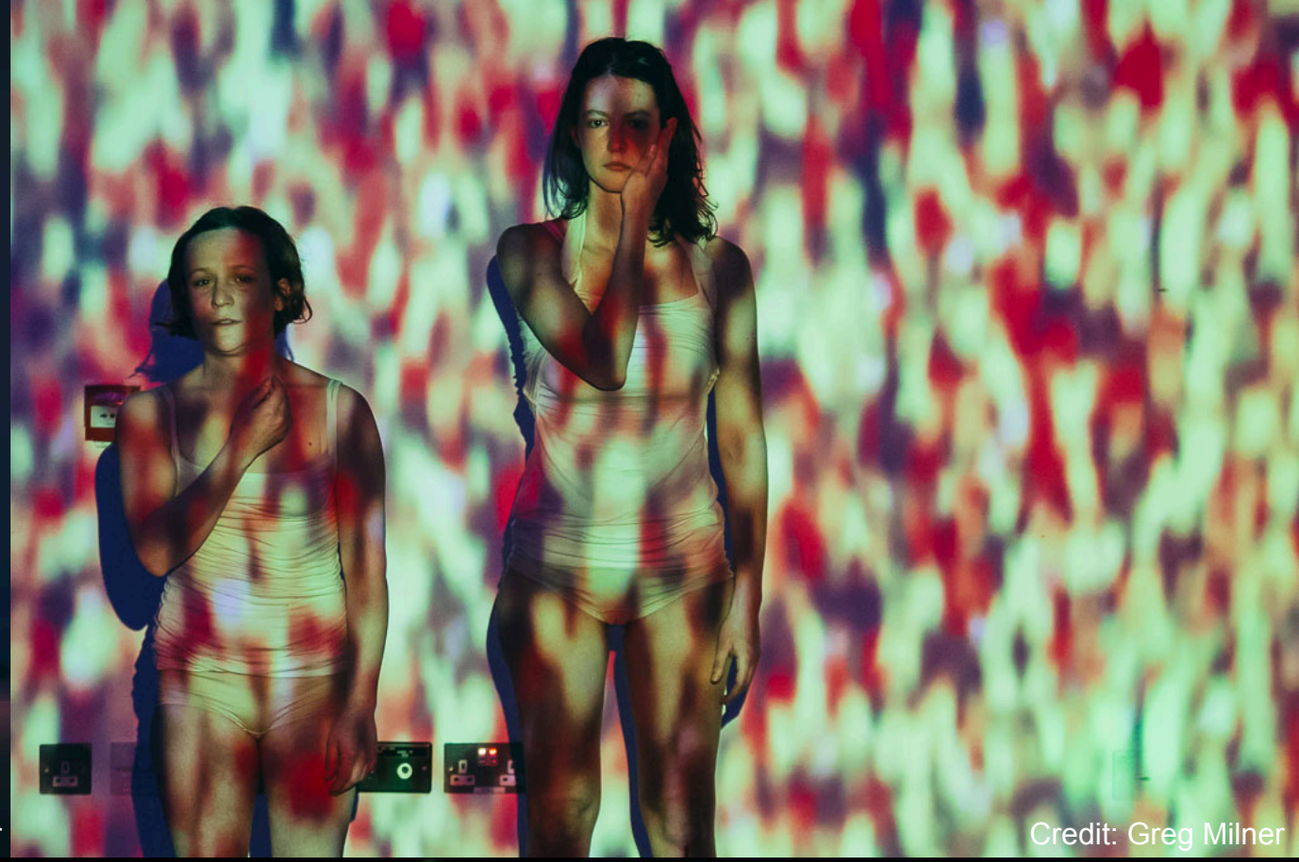
Credit: Greg Milner


Credit: Greg Milner


Credit: Heidi Marier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The Neutrino Passoire

https://www.youtube.com/watch?v=X-5rkIuNbLY

PAPER

Phys. Educ. **53** (2018) 054001 (8pp) iopscience.org/ped

Introducing particle physics concepts through visual art

I Andrews[1] and K Nikolopoulos[2]

[1] In-Public, Community arts group, Birmingham, United Kingdom
[2] School of Physics and Astronomy, University of Birmingham, B15 2TT, United Kingdom

E-mail: k.nikolopoulos@bham.ac.uk

Abstract

The development of a workshop using the language, techniques, and processes of visual art to introduce particle physics concepts is described. Innovative delivery methods committed to the interaction and collaboration of different specialist areas are utilised, which—in curriculum terms—encourages connections to be made between separate subjects to the benefit of both. Beyond enhancing the understanding of the nature of the microcosm, this approach aims to stimulate a 'creative curiosity' about the world.

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- A wide range of artistic techniques explored
  - Drawing
  - Sculpture
  - Performance art
- "Art school" experience
  - Activity inter-connection → Scientific concepts reinforced
  - Work and methods artistically/scientifically valid
  - Workshops beneficial for art students
- Art and Science on equal footing
  - Support for innovative curriculum design
  - Promoting inter-disciplinary collaborations
- Initial implementation focused on students aged 14–16

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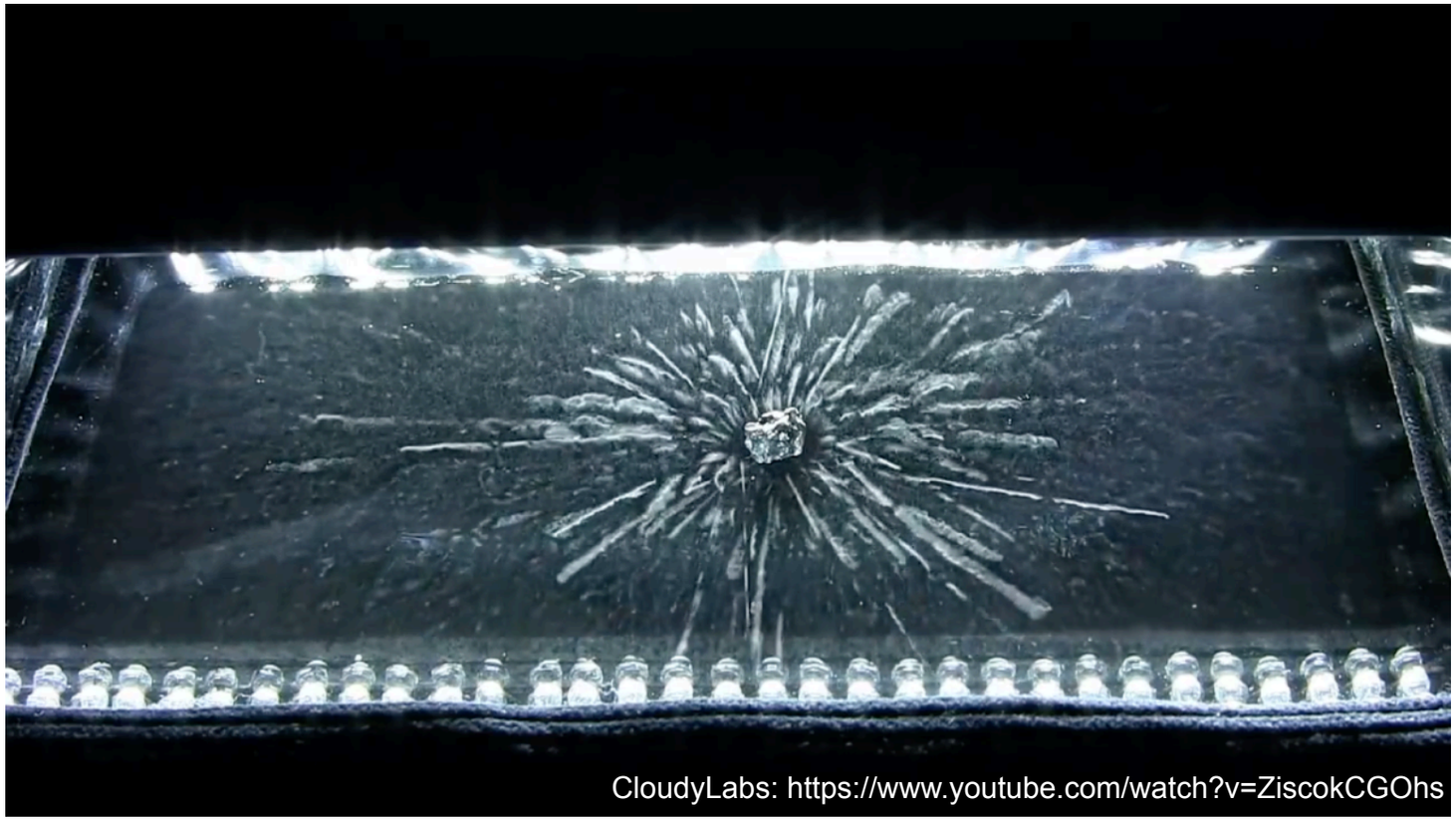
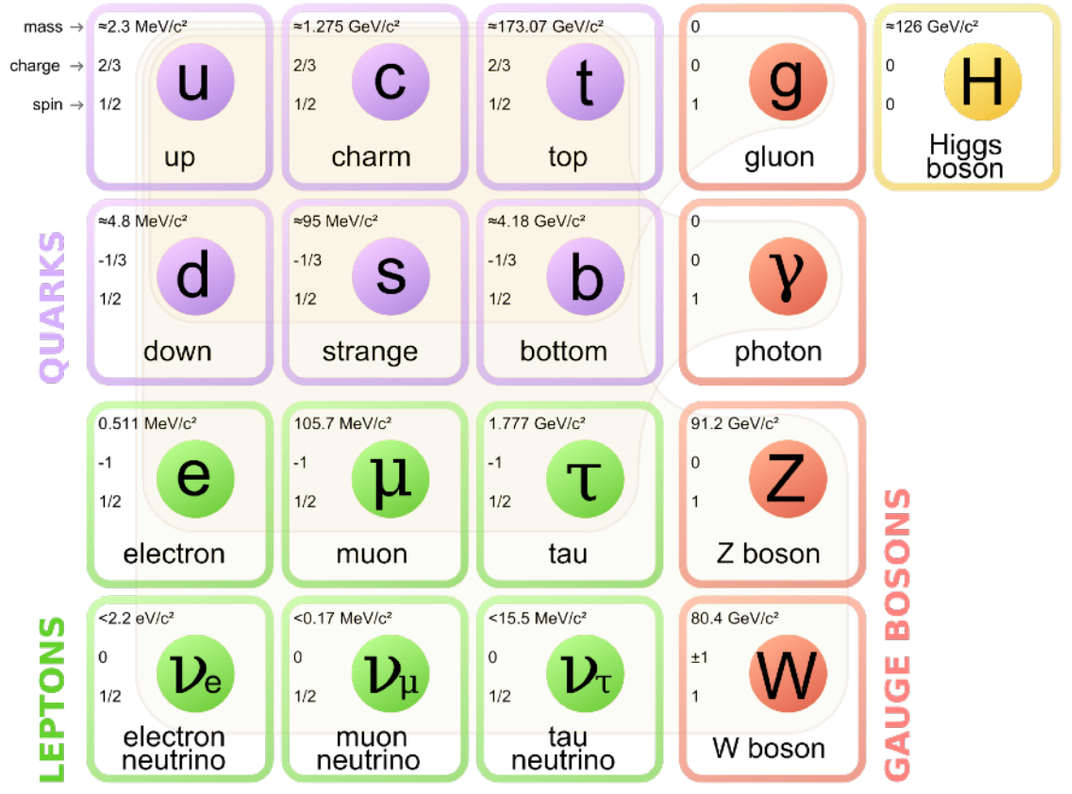
Activity	Description	Duration (min)
Discussion	Standard Model particles and interactions	20
Discussion	Art-science collaborative examples	10
Drawing	Charcoal and putty rubber exercise	45
Critique	Reviewing the 'ideas' sheet	15
Drawing	Pen and pencil exercise	20
Drawing	Experimental mark making exercise	15
	Break	
Discussion	Open questions: dark matter and dark energy	15
Sculpture	Materials manipulation and light-box experiments	30
Perfor-mance	Devise and film shadow screen performance	30
Critique	Reviewing the completed 'ideas' sheet and films	15


CloudyLabs: https://www.youtube.com/watch?v=ZiscokCGOhs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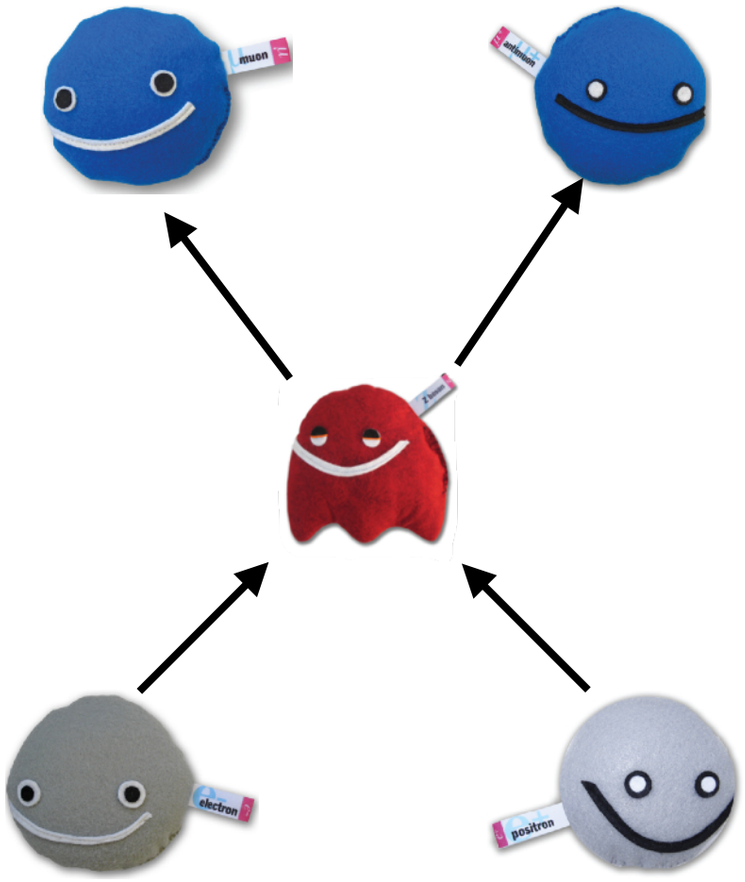
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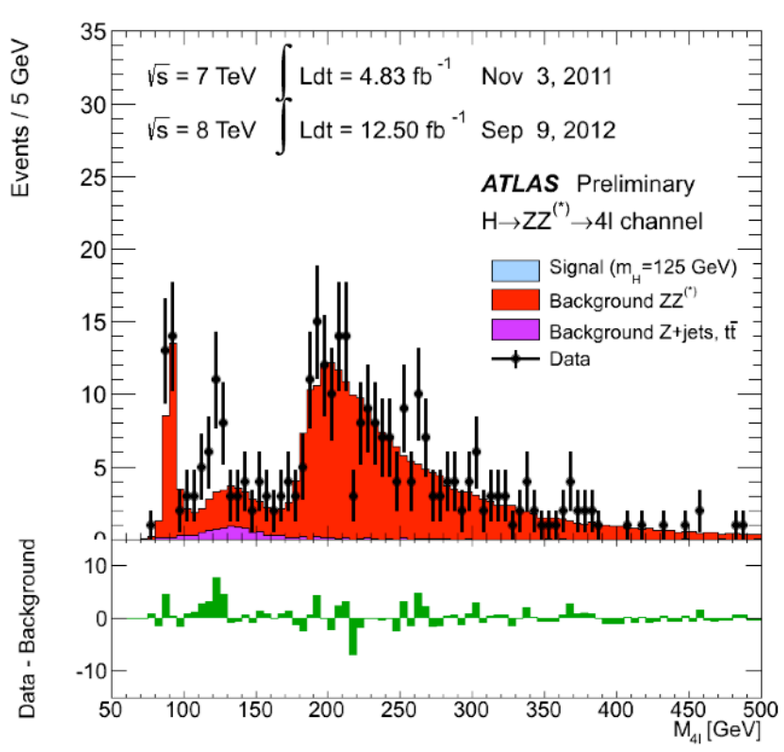
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√s = 8 TeV ∫Ldt = 12.50 fb⁻¹ Sep 9, 2012
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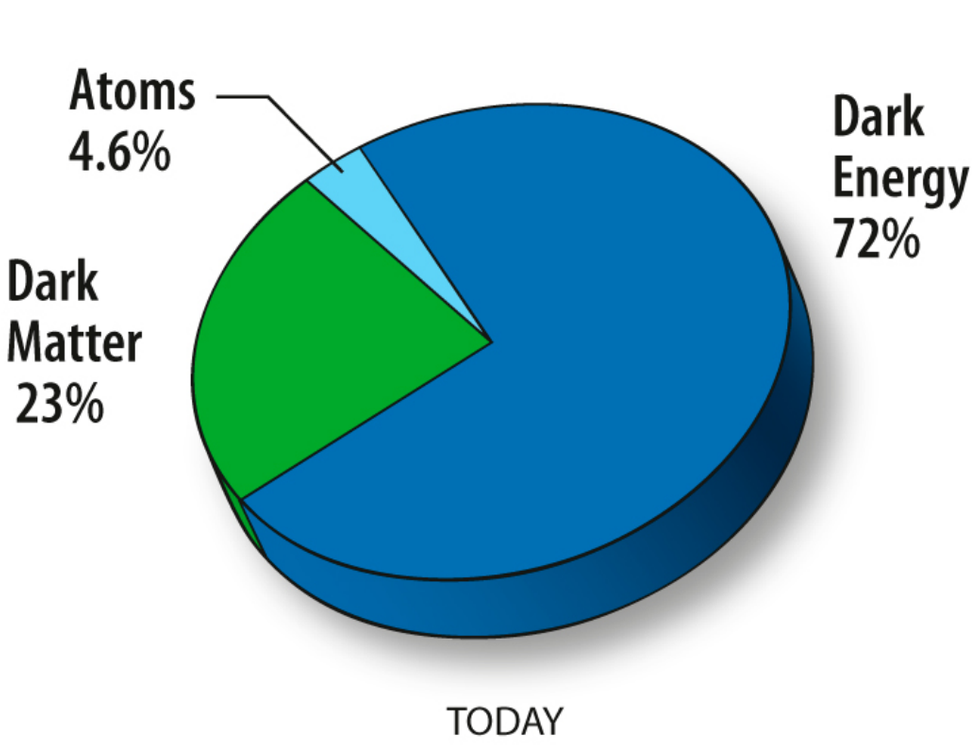
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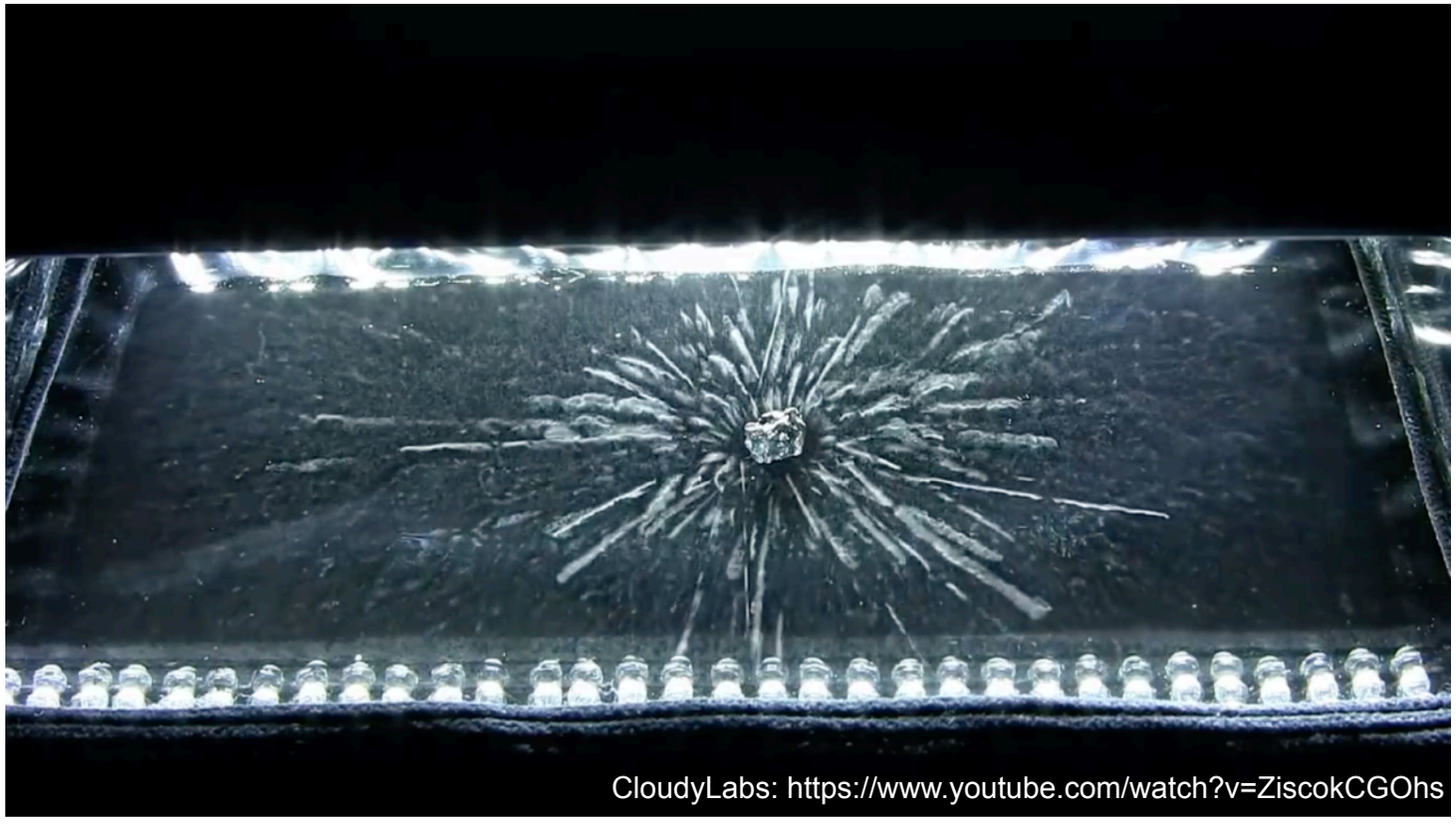
Matter
23%
Dark
Energy
72%
TODAY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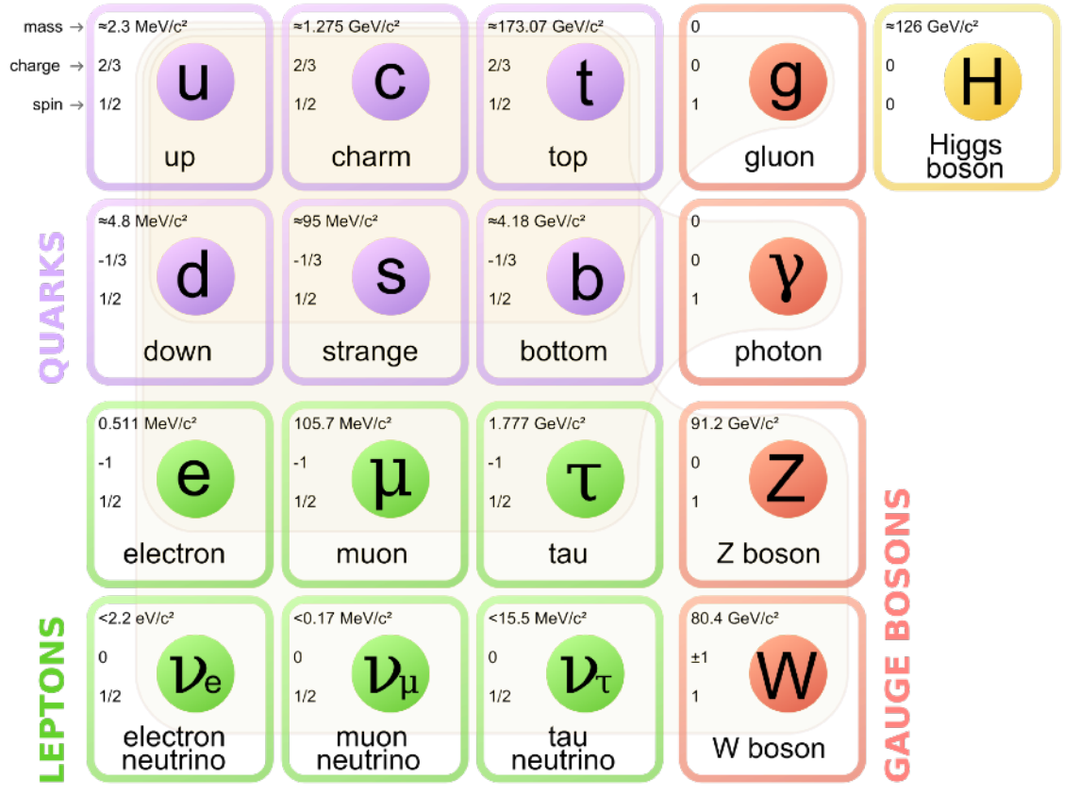
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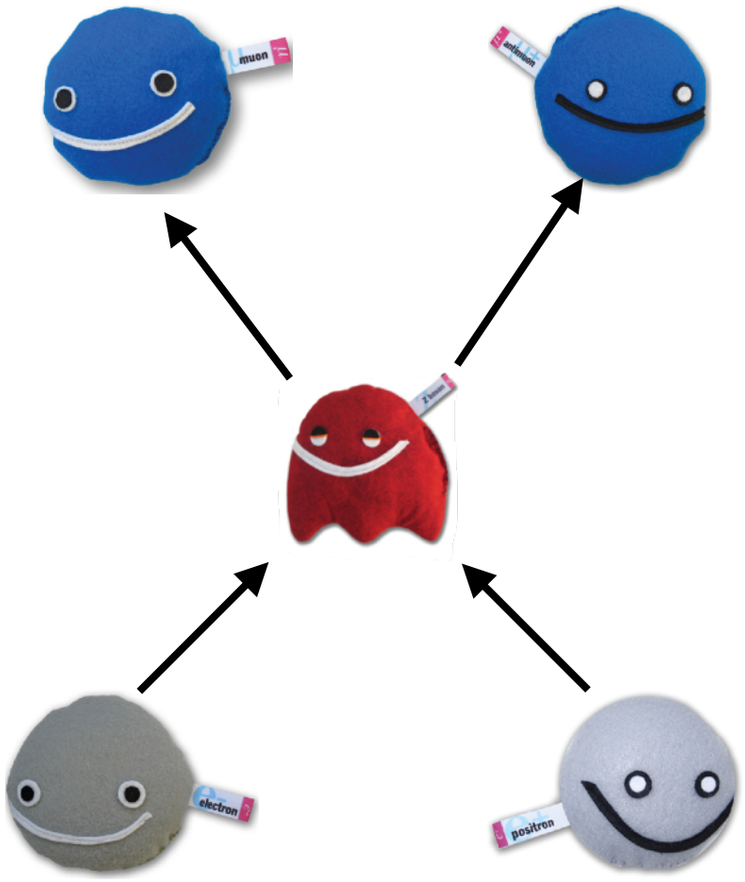
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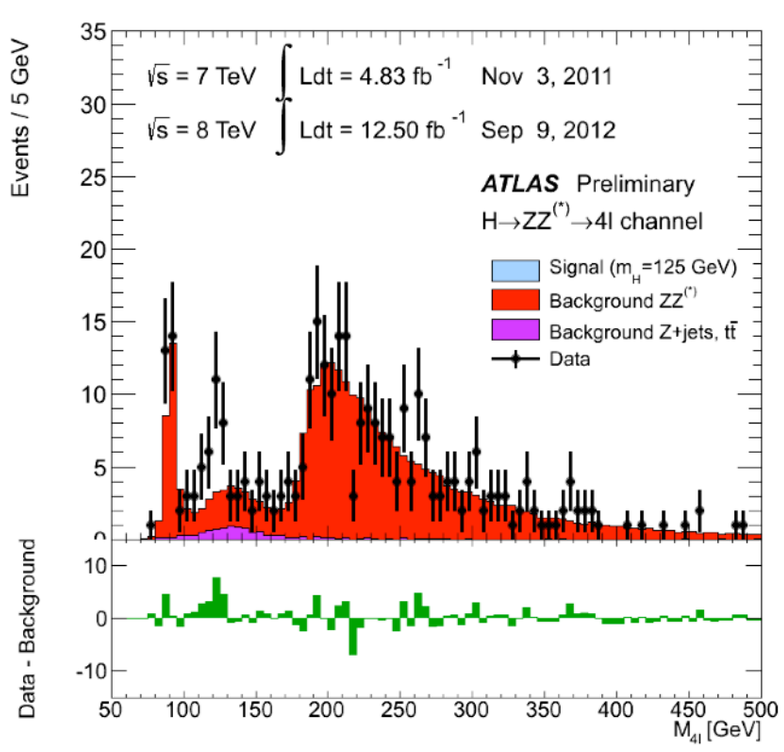
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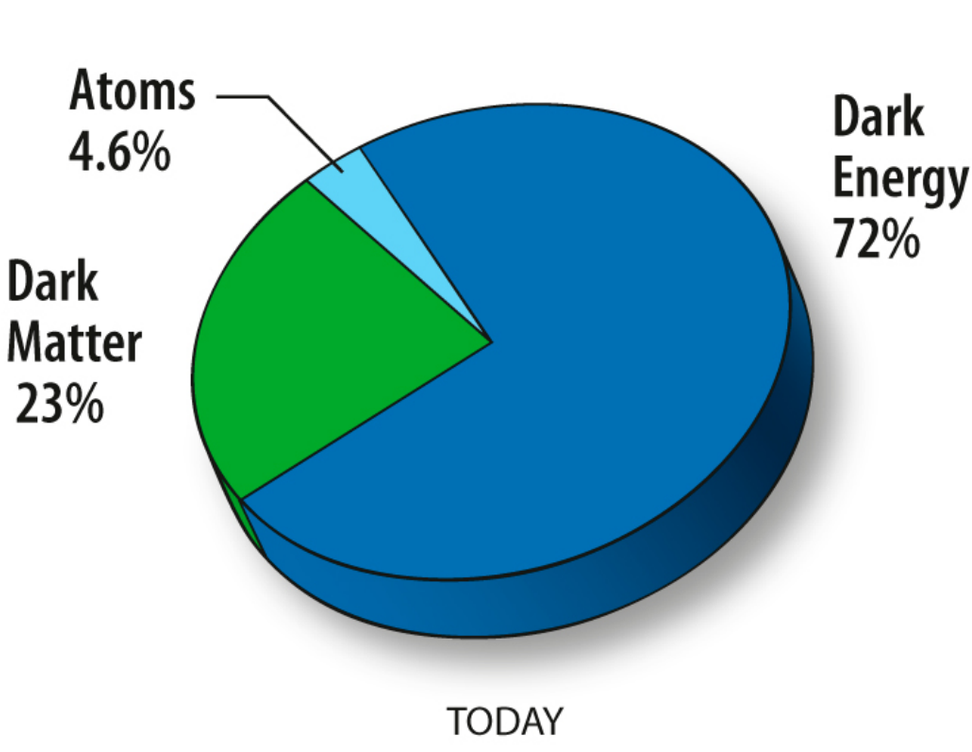
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TODAY

Drawing: Charcoal

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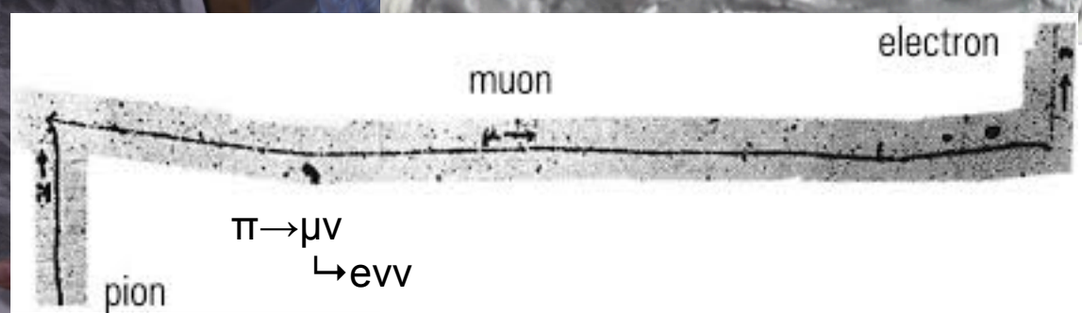
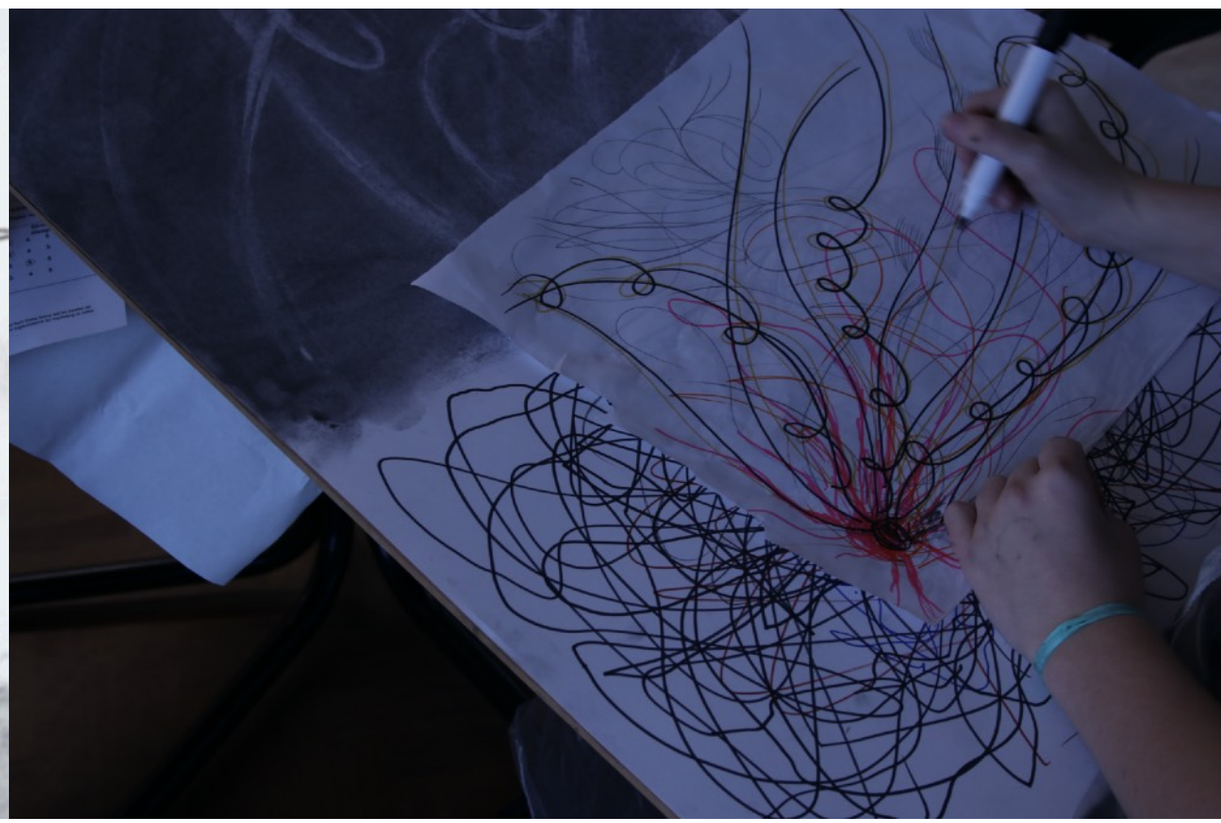
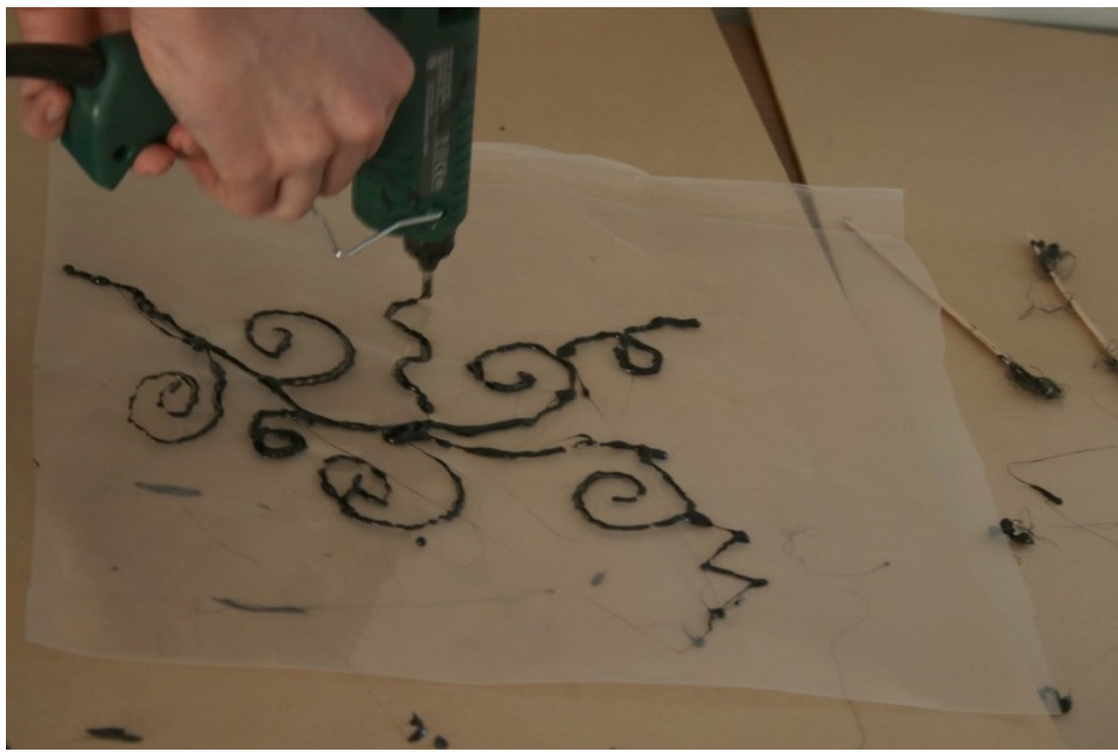


Students not shown anything similar

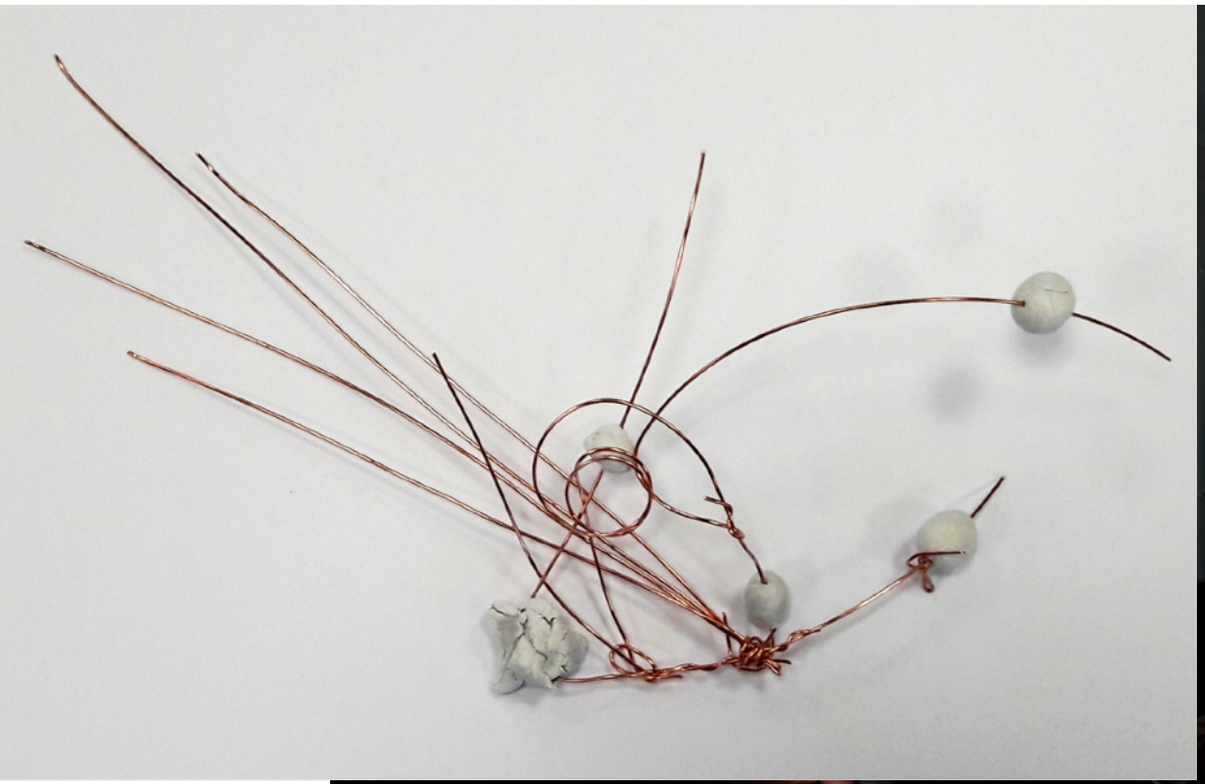
Drawing: Pen&Pencil/Experimental Mark Making

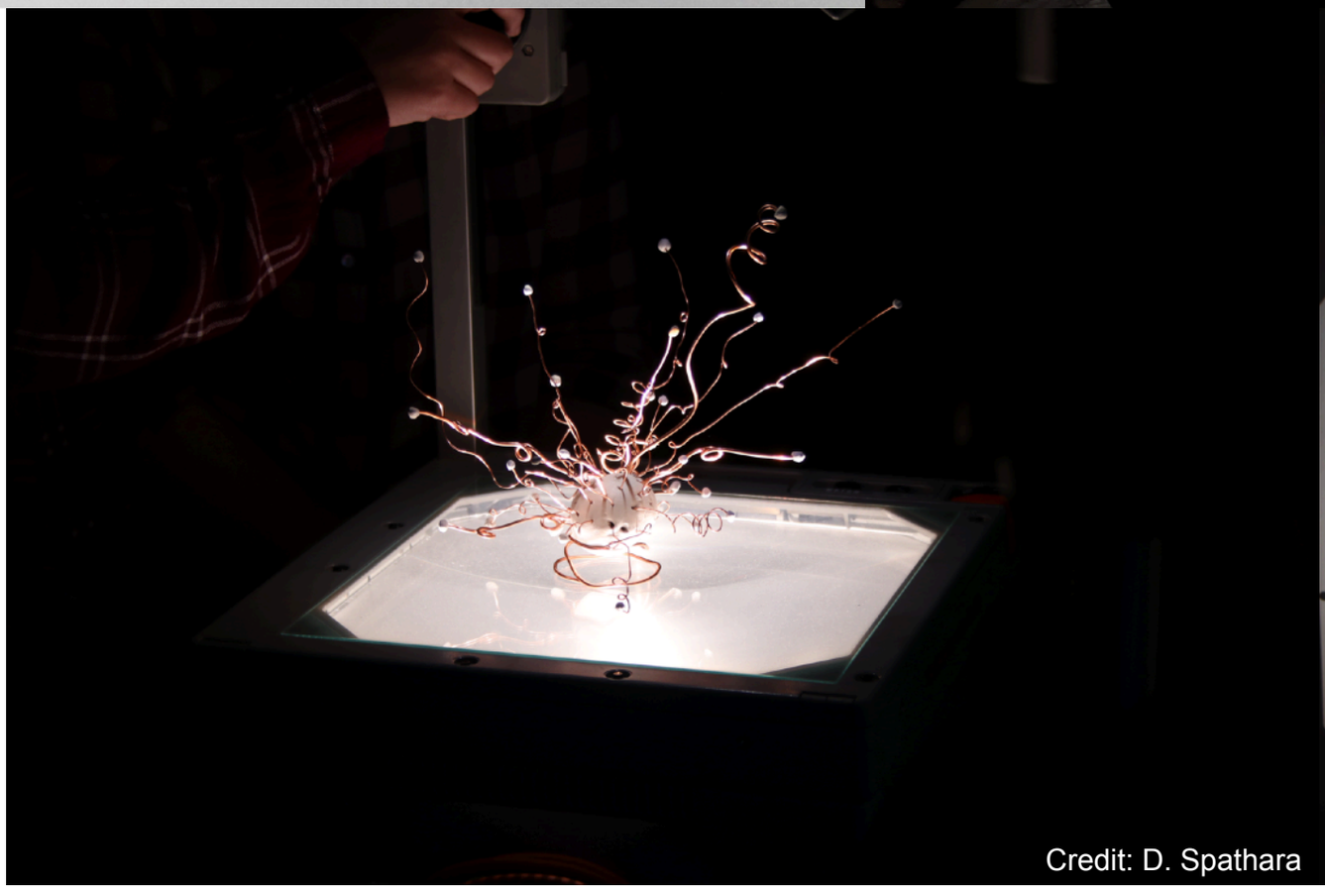


- Drawing exercises gradually more abstract
  - require greater contextualisation
- Explore collaborative drawing
  - Surrealists exquisite corpse
  - Students dislike someone else intervening
    - Discuss about collaboration
- Definition of drawing to extreme: “Glue guns”
  - mirroring experimental nature of visual art practice

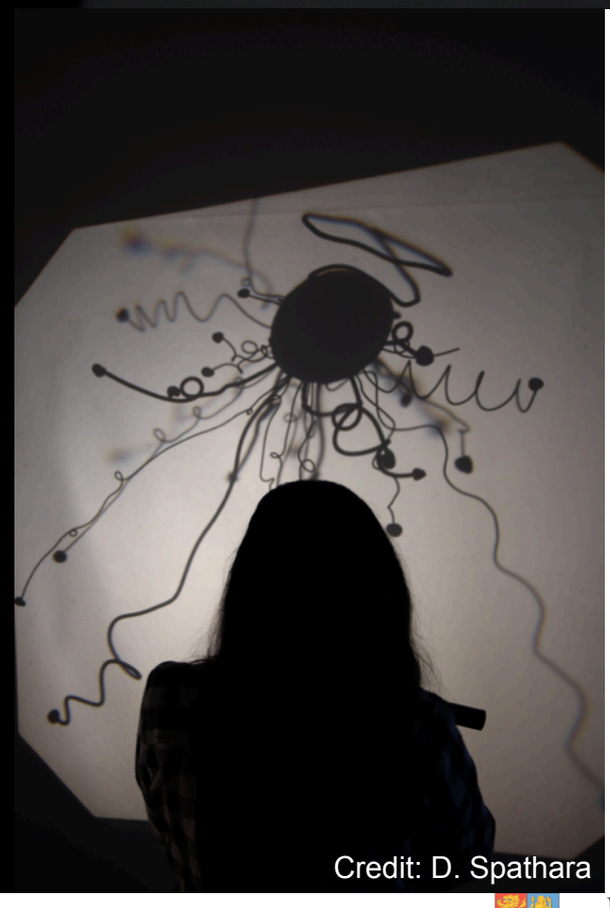


Sculpture





Credit: D. Spathara



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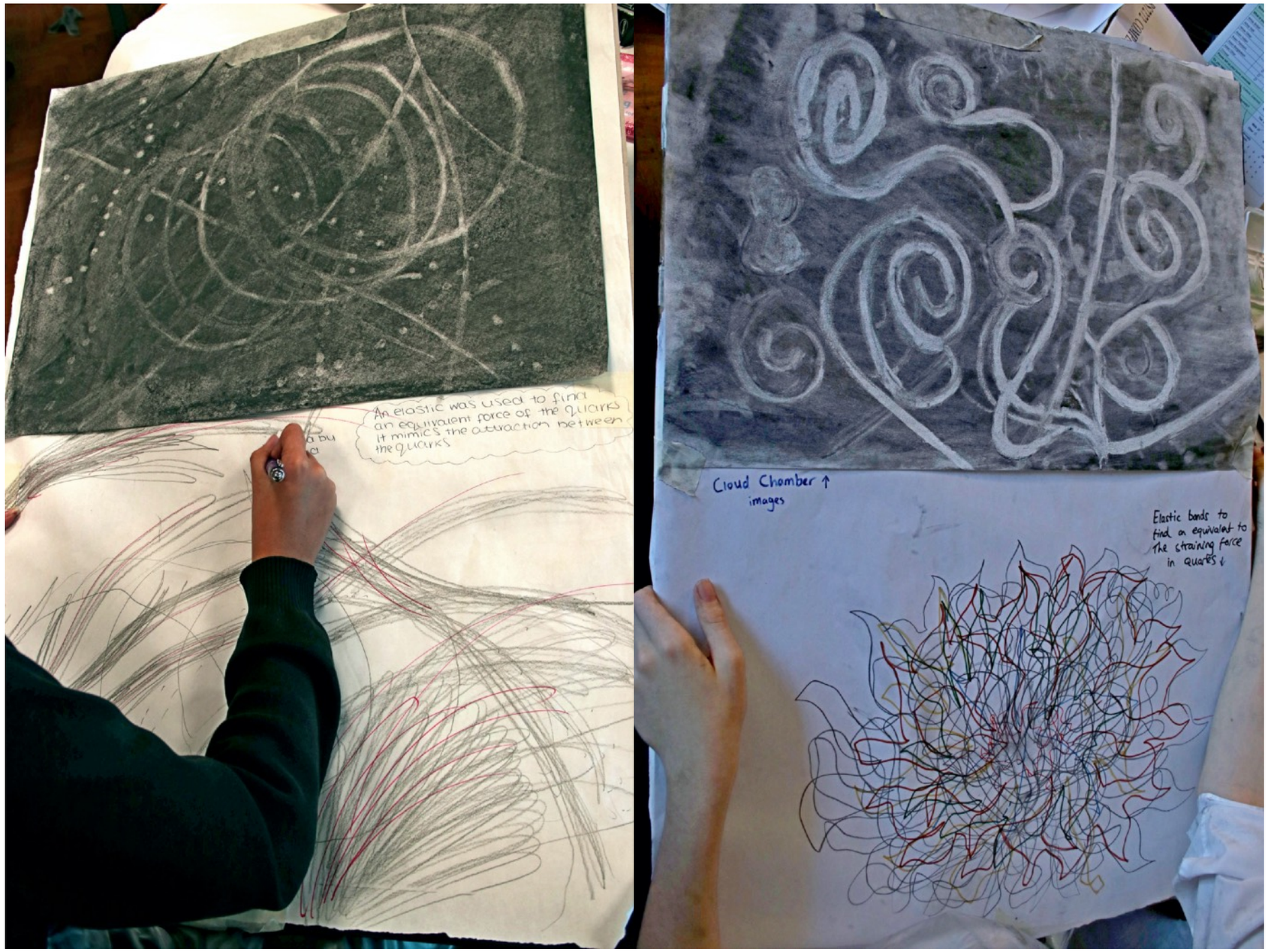
Shadow Screen Performance

Shadow Screen Performance

“Ideas” sheet



- Each outcome placed on a single A1-sized “ideas” sheet
  - Complete artistic “product” being developed
  - Annotated with scientific explanations
  - Students take ownership

Critique

- The “ideas” sheet becomes the focus of a series of group critiques
  - Concludes with an overall critique of the complete body of produced work
  - Both artistic choices and scientific context is discussed
  - Further reinforce key concepts and dispel any misconceptions
- Parallels to the scientific seminar
  - Progress relies on scientists presenting, discussing, and improving their results

Art term for seminar!

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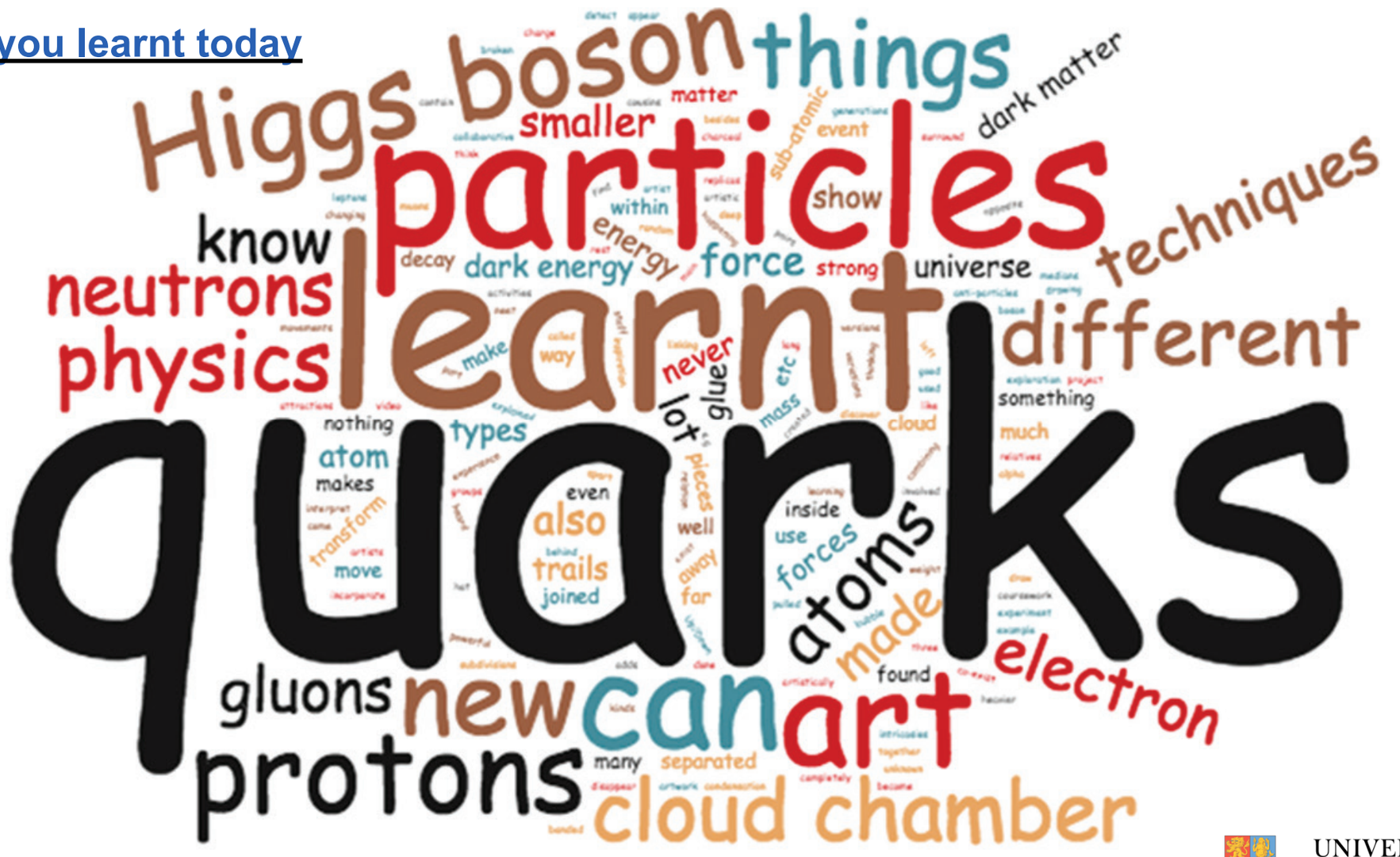
Evaluation

- Evaluation of workshop using pre-/post-event questionnaires
- Following the event
  - ~80% of students declared an increased interest in physics
  - ~35% of students said they were more likely to study physics at university
    - ~20% among students not originally inclined to study physics
  - ~75% of students considered physics to be a more accessible subject,
    - ~65% among students initially considering physics an accessible subject

Describe one thing that you learnt today



OPEN ACCESS arXiv:1912.11128 Made open access 19 February 2020 PAPER

Phys. Educ. **53** (2019) 025018 (6pp) iopscience.org/ped

Particle dance: particle physics in the dance studio

K Nikolopoulos[1] **and M Pardalaki**[2]

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A workshop using dance to introduce particle physics concepts to young children is presented. The workshop is realised in the dance studio, the children assume complete ownership of the activity and dance becomes the means to express ideas. The embodiement of the physics concepts facilitates knowledge assimilation, while empowering the students with respect to science. Beyond the scientific and artistic benefits of this workshop, this approach aspires to overcome the barriers between art and science; and open new interdisciplinary horizons for the students.

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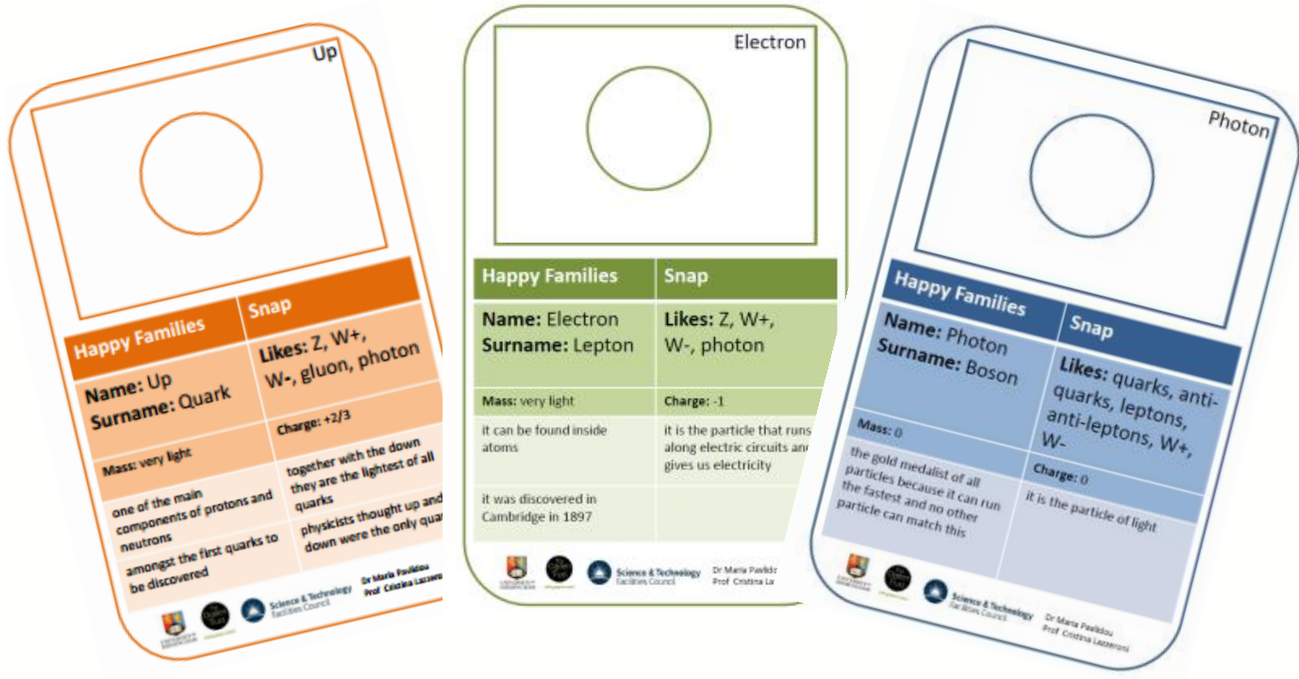
- Core idea: particle physics in the dance studio
  - informal learning
  - avoid science classroom pre-conceptions
  - allow interdisciplinary connections
- Mutual benefits!
  - Students appreciate dance as means to express/convey ideas
- Bridging art and science subjects
  - currently disconnected in the curriculum
- Crucial that students have a complete artistic creation, that they can perform/discuss
- Initial implementation focused on girls aged 12–13

Workshop Structure



- Standard Model particles
  - Students connect particles to dance with short choreographic movements, proposed by themselves, inspired by the particle properties, name, etc
  - All movements combined in single choreography
- Anti-matter and particle interactions (scattering, pair-production and annihilation)
  - Teams of 3, 5, or 7 persons to choreograph an interaction
  - Students complete responsibility for choreography → including choice of music
  - Discuss collaborative aspects of research
- Finally, discuss physics beyond the Standard Model
  - Variable reactions: most excited and interested, some disappointed.
  - A student actually got upset, almost angry, not being able to accept the revelation!

Video: D. Gayoso-Miranda

- Following the discussion and the first exercise, students were able to re-assemble the Standard Model using the “sub-atomic particle plushes” (https://www.particlezoo.net/)

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Credit: D. Spathara

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- Live music, and particularly students choosing the music, proved extremely powerful!
  - Cornerstone of students taking ownership of the choreography
  - In typical dance lesson students are given a song/piece of music to dance to
  - The workshop approach was ground-breaking for them

Evaluation

- Workshops finish with round table
  - feedback on workshop/suggestion for improvements
- Feedback also from dance teachers
- Overall, received feedback has been particularly encouraging
  - Students keen to respond → Striking difference with their reluctance at the beginning
- Excited about all the different particles and that they appear/disappear through interactions!
  - Most thought atom is smallest division of matter

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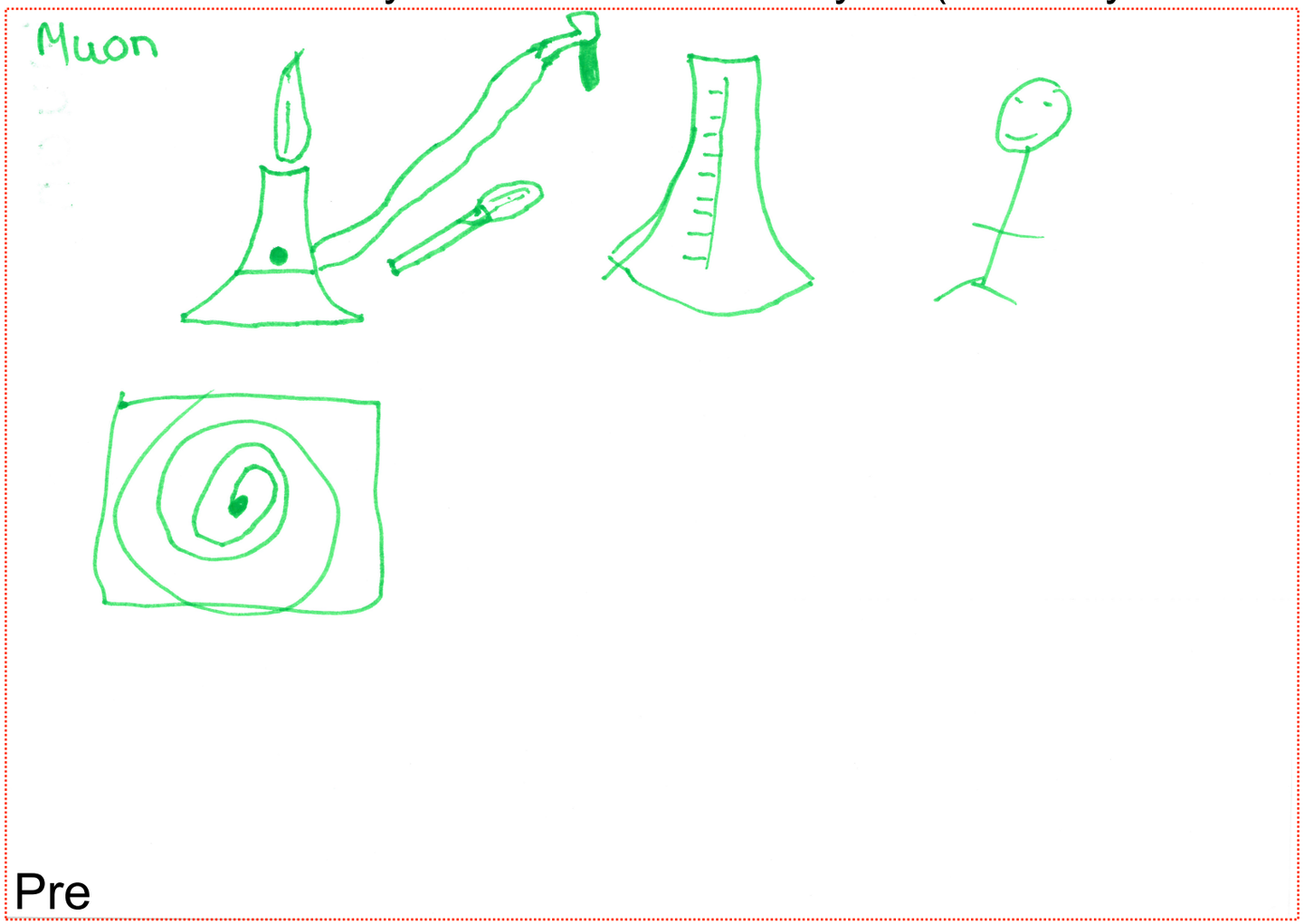

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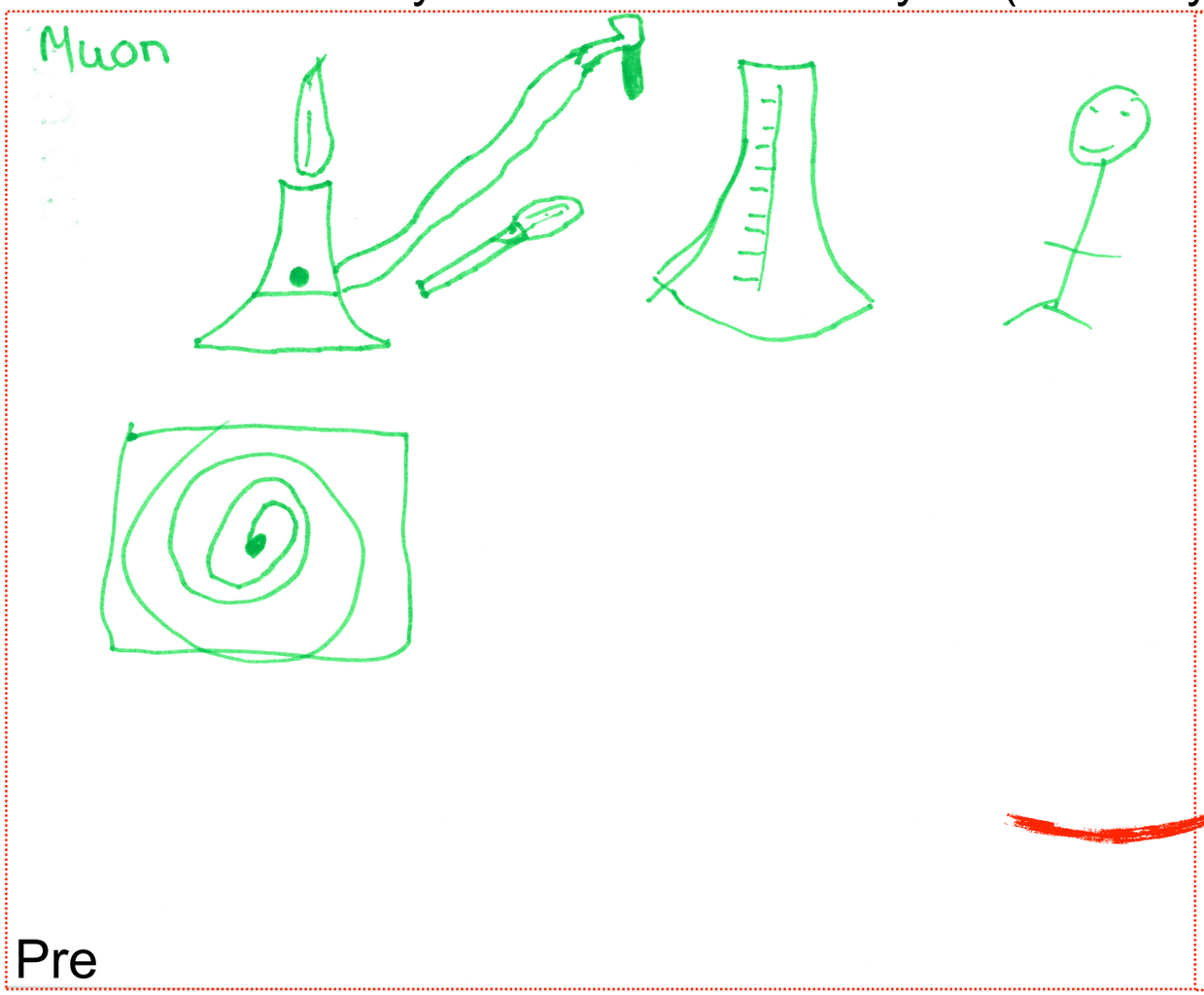

Pre

Post

Evaluation

- Prior to event students had little idea of what it would involve
  - Expressed surprise at how physics and dance came together so naturally!
  - They found the event different and unusual
- Excitement about the creative aspect
  - Collaboration noted too!
- Obtaining an “end product” combining both parts of the workshop proved crucial
  - Interleaving physics with dance beneficial for understanding

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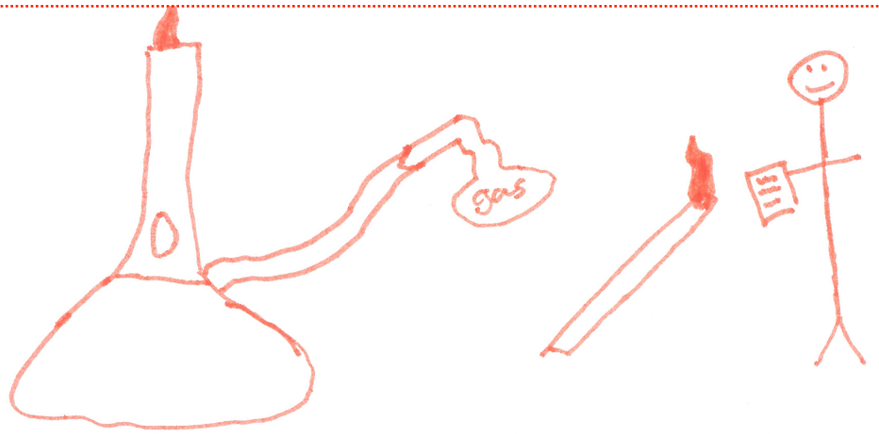
> “I always thought it was just one atom and there were just electrons going around it. But actually there is so much more to it!”

Evaluation



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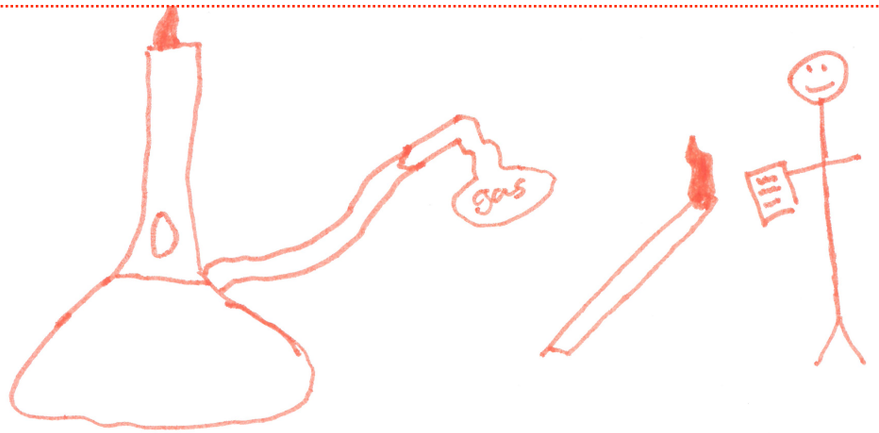
gas

Pre

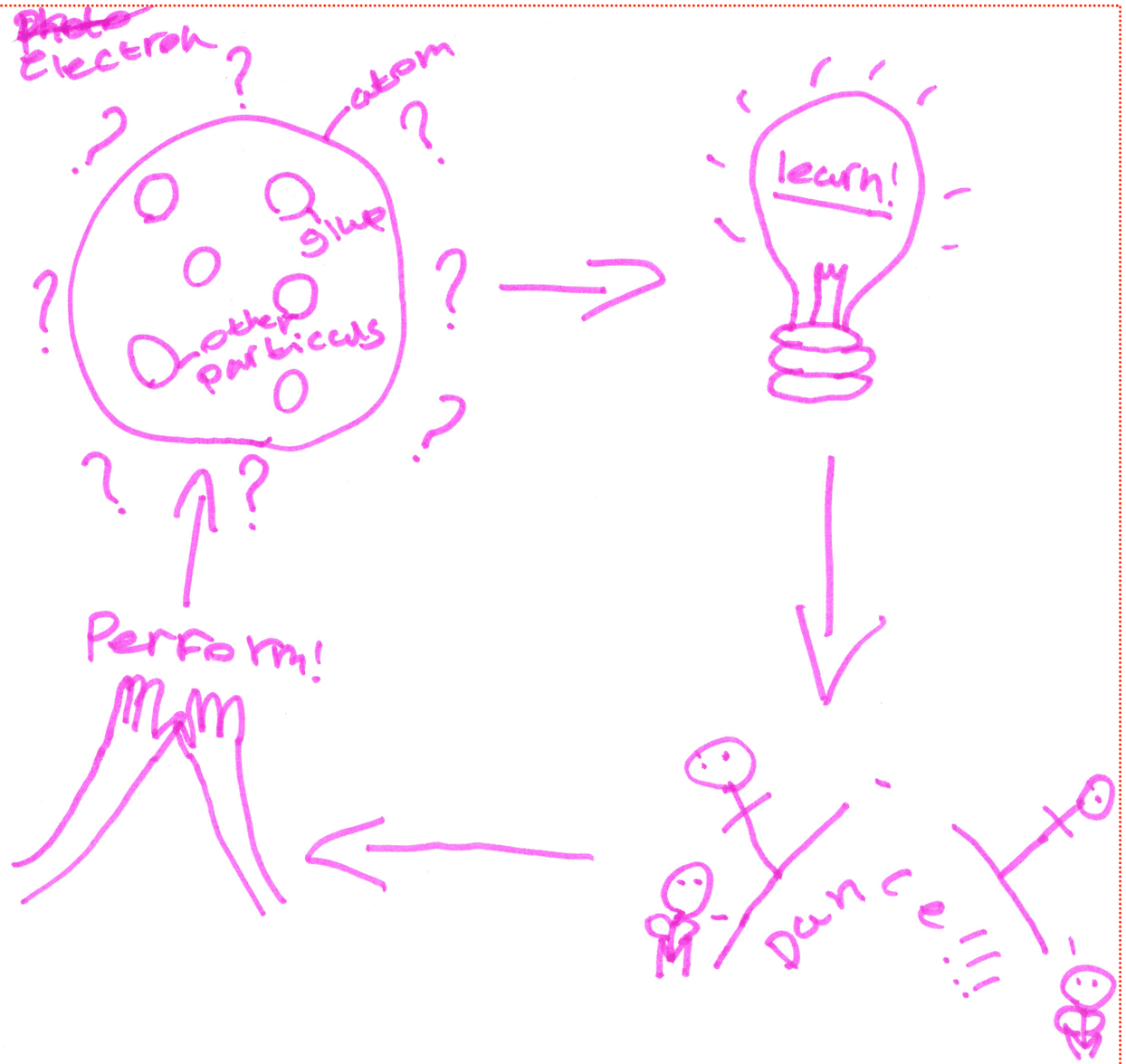
Photo
Electron
atom
glue
other particles
learn!
Perform!
Dance!!!

Post

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Dialogue and materiality/embodiment in science|arts creative pedagogy: Their role and manifestation

K. Chappell[a,*], L. Hetherington[a], H. Ruck Keene[a], H. Wren[a], A. Alexopoulos[b], O. Ben-Horin[c], K. Nikolopoulos[d], J. Robberstad[c], S. Sotiriou[e], F.X. Bogner[f]

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[e] Ellinogermaniki Agogi, Dimitriou Panagea Str., GR 153 51 Pallini Attikis, Greece
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- Explored interaction between science, arts and their inherent creativity to better understand their teaching and learning potential
  - Focus: Dialogue and materiality/embodied activity manifestation within creative pedagogy
  - "Diffractive analysis": series of research assemblages in response to arising questions
- Personally found the process very interesting. Never done something similar before!
  - Many insights and new questions!

> *…gave the opportunity to shine a light on the topic from many different angles. This generated different reactions to the analysers, which subsequently resulted to unexpected insights in the data – ones that were not anticipated. It is indeed a diffractive process, where beyond letting the data unveil their own story, did actually change (to various extents) the way the analysers think. In modern physics, diffraction occurs when a particle passes an obstacle through different slits, and results – by constructive and destructive interferences – to very interesting – and insightful – patterns. It seems that our different backgrounds correspond to the different slits. (post-discussion document, Kostas)*

Summary

- Developed science|art workshops to introduce particle physics to students
  - Replicating the process used in working with artists
- Two strands:
  - Visual Arts
  - Dance
- Connections between the two disciplines
  - Both given equal weight in the workshops!
- Positive outcomes
  - Empowering students towards science!
- Awarded ERC Public Engagement with Research Award

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Developing an Engaging Science Classroom

IOP Institute of Physics

erc
European Research Council
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> The workshop was so good - everyone came away with a real buzz. From conversations afterwards and watching them during the day, they all really enjoyed taking part and it was lovely to see them so engrossed!
> What I learned was
> a) the power of getting pupils to visualise new and complex ideas in different ways and
> b) not to stereotype our students who proved they can cope with, and enjoy being presented with, very challenging ideas away from the exam system
>
> Teacher feedback

Credit: D. Spathara


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