Leading education and social research
Institute of Education
University of London

Science Education in the 21st Century

Professor Michael Reiss

www.ioe.ac.uk

University of Iceland
5 June 2013

The context of this talk

- **The curriculum**
- **Pedagogy**
- **Assessment**
- **Understanding of science**
- **Participation in science**
- **Science education should be true to science and true to education**

Leading education and social research
Institute of Education
University of London

Hattie (2011): *Learning for Teachers: maximizing impact on learning*, Routledge

- **A league table of 150 factors and their effects on learning – everything from things like the use of formative assessment to whether classes are mixed ability, class sizes, holding students back a year**
- **Arranged in terms of decreasing ‘effect sizes’**
- **An effect size of 1 is roughly equivalent to increasing the rate of learning by 50%**
- **Let’s look at the top 10 of these 150**

Hattie (2011) – top 10

1. **Self-reported grades (ES = 1.44) He now calls this 'student expectations' – enabling students to do better than they think they are going to do**
2. **Piagetian programmes (ES = 1.28) (e.g. CASE)**
3. **Early interventions to prevent academic failure (ES = 1.07) (e.g. Reading Recovery)**
4. **Teacher credibility (ES = 0.90)**
5. **Providing formative evaluation (ES = 0.90)**
6. **Micro teaching (ES = 0.88)**
7. **Classroom discussion (ES = 0.82)**
8. **Comprehensive interventions for SEN students (ES = 0.77)**
9. **Teacher clarity (ES = 0.75)**
10. **Feedback (ES = 0.75)**

Oates (2010) *Could do Better*

Control factors:

1. **Curriculum content (national curriculum specifications, textbooks, support materials, etc.)**
2. **Assessment and qualifications**
3. **National framework – system shape (e.g. routes, classes of qualifications)**
4. **Inspection**
5. **Pedagogy**
6. **Professional development (levels and nature of teacher expertise)**

Oates (2010) *Could do Better* (cont.)

7 Institutional development

8 Institutional forms and structures (e.g. size of schools, education phases)

9 Allied social measures (such as that which links social care, health care and education)

10 Funding

11 Governance (autonomy versus direct control)

12 Accountability arrangements

13 Selection and gatekeeping (e.g. university admissions requirements)

True to Science

- Reaching scientific conclusions
- Reaching mathematical conclusions
- Reaching ethical conclusions
- Teaching aesthetic conclusions

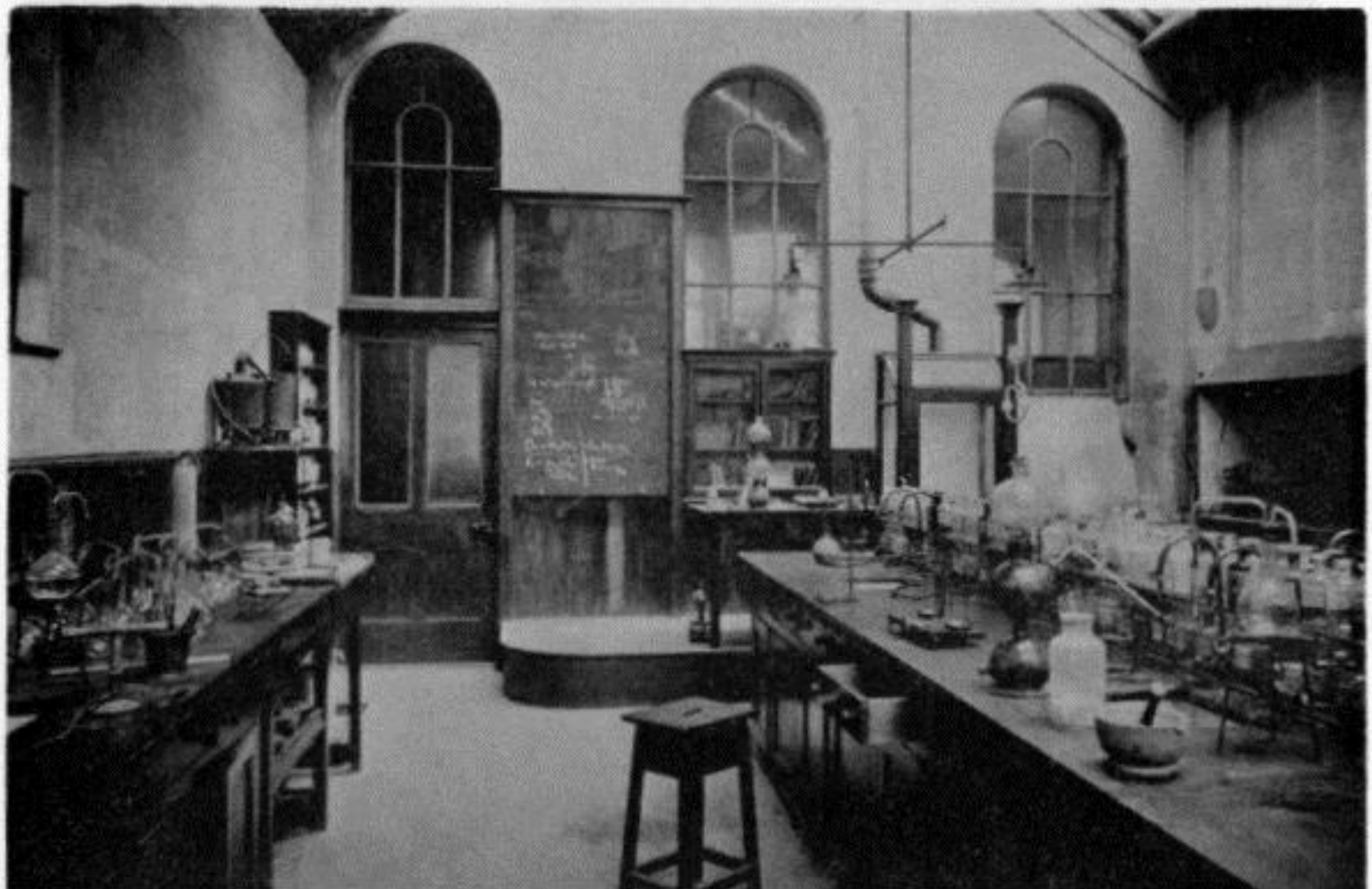
Working scientifically

- Biology, Chemistry, Physics
- Earth sciences, Astronomy, Electronics
- Archaeology, Geography, History
- Psychotherapy
- Bovine TB

Leading education and social research
Institute of Education University of London

Laboratory work and Fieldwork

The job of science is to uncover the laws of nature. However, nature is far too complex for students to be able to do this. The best way forward is therefore to ensure that students learn science in school laboratories. In such laboratories, variables can be controlled so that students can see that in the absence of friction, objects do continue to move at constant velocity; that crystals of sodium chloride can be dissolved in water and reconstituted once the water evaporates; that silt sediments more slowly than sand; and that respiring organisms produce carbon dioxide and water vapour.

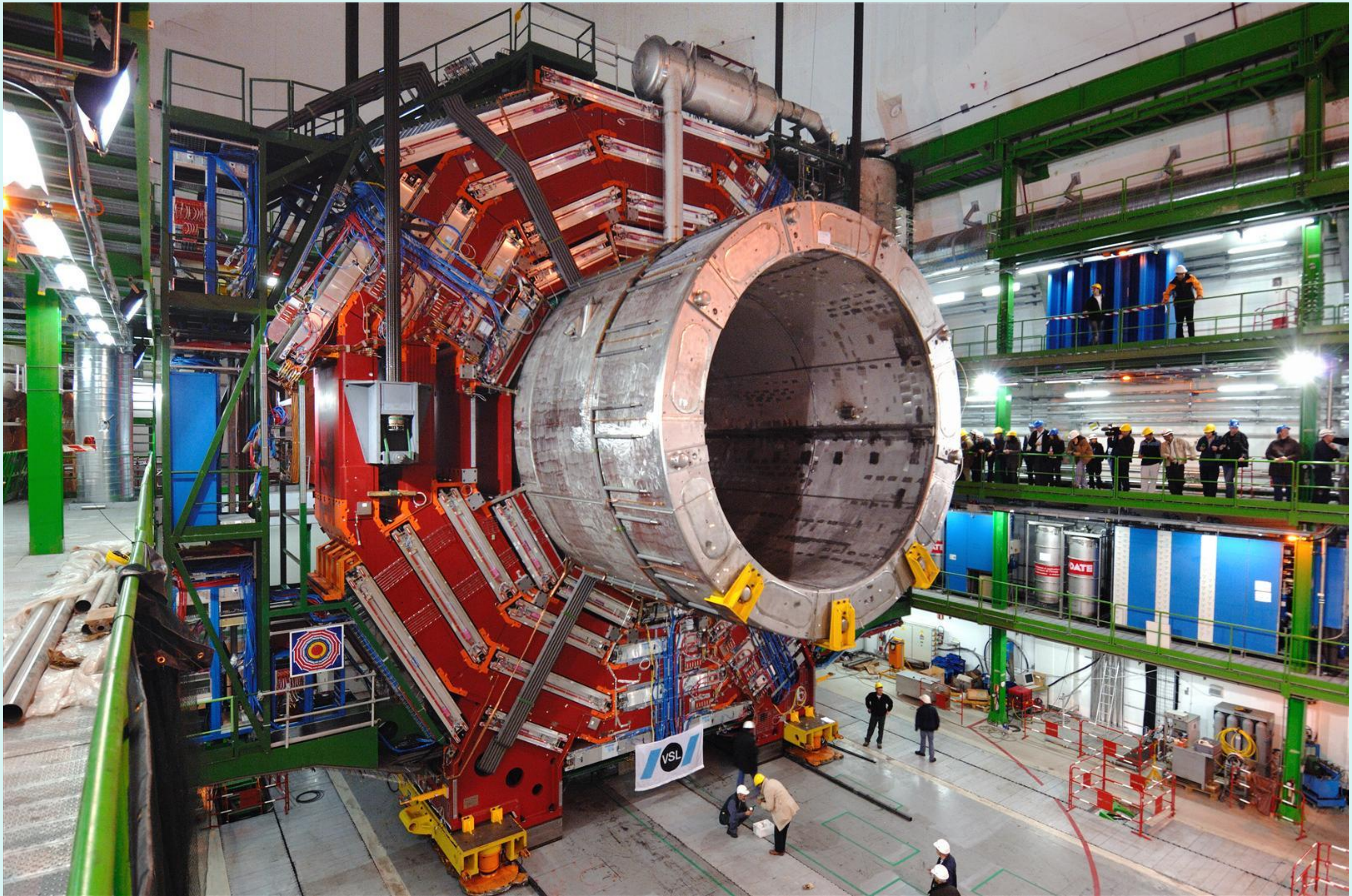


CHEMISTRY LABORATORY

IOE LONDON

Leading education and social research

Institute of Education University of London




Capital
Campaign
Donors
State of Ohio
City of Columbus

Models of reality

- Reality is complex so we need to simplify (school lab)
- Galileo
- The context, the macro level, the invisible (micro in chemistry, past in many other sciences), the model / representation of reality

Leading education and social research
Institute of Education University of London

Diversity of practical work

- **Specific practical skills**
- **Investigations**
- **Conceptual understanding**
- **Implications for assessment**

Outsider Science?

Leading education
and social research
Institute of Education
University of London


SUNDAY
SUNDAY'S CRASH

Outsider Science

- **Creationism**
- **Climate denial**
- **Alien abduction**
- **Astrology**
- **Conspiracy theorists (Outsider History)**

True to education

- **Aims of education**
- **Flourishing (self and others)**
- **An aims-based curriculum (Reiss & White)**
- **“A central aim of the school should be to prepare students for a life of autonomous, whole-hearted and successful engagement in worthwhile relationships, activities and experiences.”**

Skills that others are calling for

US National Academies (2011) *Assessing 21st Century Skills*

- **Cognitive Skills**
- **Interpersonal Skills, e.g.**
  - Develop, implement, and communicate new ideas to others effectively
  - Articulate thoughts and ideas effectively using oral, written, and nonverbal communication skills in a variety of forms and contexts
- **Intrapersonal Skills, e.g.**
  - Adaptability
  - Self management

True to science education

- **Formal / informal science learning**
- **Lifelong learning**
- **Academic / pure and vocational / applied science**
- **The capacity of new technologies to increase the ‘permeability’ of the school science laboratory and school science textbooks**
- **Greater criticality**

Greater criticality

- **E.g. variation: the elements, wheat plants, sheepdogs, oak trees, people**
- **E.g. Down's Syndrome**
- **E.g. human sex: XX, XY, intersex; hormones, transgender – the capacity of school science to help challenge heteronormativity**

Leading education and social research
Institute of Education University of London

Choosing science

One of my main conclusions from the study was that school science education can only succeed when pupils believe that the science they are being taught is of personal worth to themselves. Here, ‘personal worth’ should not be understood too narrowly. For many pupils, science is of value only in so far as it is of instrumental use, for example for subsequent education. Other pupils, though, search for meanings and may feel that science can help them to understand their place in the world. Such diversity among pupils means that a science curriculum and a way of teaching science cannot assume that there is only one reason for learning about science. Unless science teaching genuinely engages with the concerns of real pupils, they will be more than capable of learning little from it. (Reiss, 2000)

Engaging science

Good science teachers engage their students. There is no standard pattern to what a student finds engaging in science. For some the awesome age of the universe is engaging; for others it is understanding Newton's equations of motion, or watching a *Paramecium* under the microscope, or realising why two grams of hydrogen react with 16 grams of oxygen, or participating in a field trip to the sea shore, or making a rocket goes as high into the air as possible, or designing an electronic circuit that works as a burglar alarm.

Rejecting science

My contention is that young people reject school science when it fails to mean enough to them, failing to connect with their developing notions of themselves. School science is perceived either as being too narrow, too safe and too predictable – 'boring' – or as being incomprehensible, even fantastic – 'irrelevant'. Unlike 'real' science, school science typically fails to provide spaces for imagination, whereas working scientists are forever asking 'what if?'.

UPMAP Strand 3: Interviews with undergraduates

- **Four UK universities**
- **Interviews with 51 first year undergraduates from population who were qualified to read either mathematics or physics**
- **Purposive sample: roughly half reading STEM and half non-STEM; range of school types; approximate gender parity.**
- **Invited via electronic communication sent out from their university and given £20.**
- **Interviews were in ‘narrative style’:**

  interviewees invited to tell their story of their educational journey;

  interviews were audio recorded and transcribed.

Leading education and social research
Institute of Education
University of London

Types of 'reason' for choice of degree subject

From an available discourse, e.g.:

- I'm good at X
- X is a high prestige subject to study
- a degree in X will be useful
- I like X

Unconscious

- participating in X serves as a defence
- participating in X is associated with desire

Sigmund Freud's central discovery:

"psychic processes are in themselves unconscious" (Freud, 1911)

Relationships are more important than enrichments

This was not only because of what interviewees said

- e.g., each referred to physics being personified in some

but also because of what they did not say

- enrichments were not mentioned by physics undergraduates as being transformative with respect to ‘choosing physics’.

Leading education and social research
Institute of Education University of London

Benjamin, reading physics with theoretical physics

I don’t know if it’s relevant cos it’s not to do with education as such but my Grandpa, he helped a lot because when I went to visit him in Spain we went for a walk and he was telling me about the stars and about the earth rotating and it’s all these new things, it was like, wow. … I didn’t see him often because he’s lived in Spain since I was about that age [10 years old]. It was just a couple of one offs put together. … he is a very practical man, very logical and I don’t know what he did before he retired, but he obviously has an interest in it [physics]. I don’t know if it’s as big as mine now, but he definitely enjoyed teaching it to me for no reason whatsoever, he just decided to teach me.

To encourage participation

- Have an imaginative projection of doing mathematics/physics in the future;
- Believe that ‘good enough’ is, indeed, good enough;
- Develop a personal, emotionally salient, view of mathematics/physics or relationships with a person/people representing physics/mathematics.

Discussion

Institute of Education
University of London
20 Bedford Way
London WC1H 0AL

Tel +44 (0)20 7612 6000
Fax +44 (0)20 7612 6126
Email info@ioe.ac.uk
Web www.ioe.ac.uk