



# ROAD MAP

Why?

WHY do we collaborate?

What?

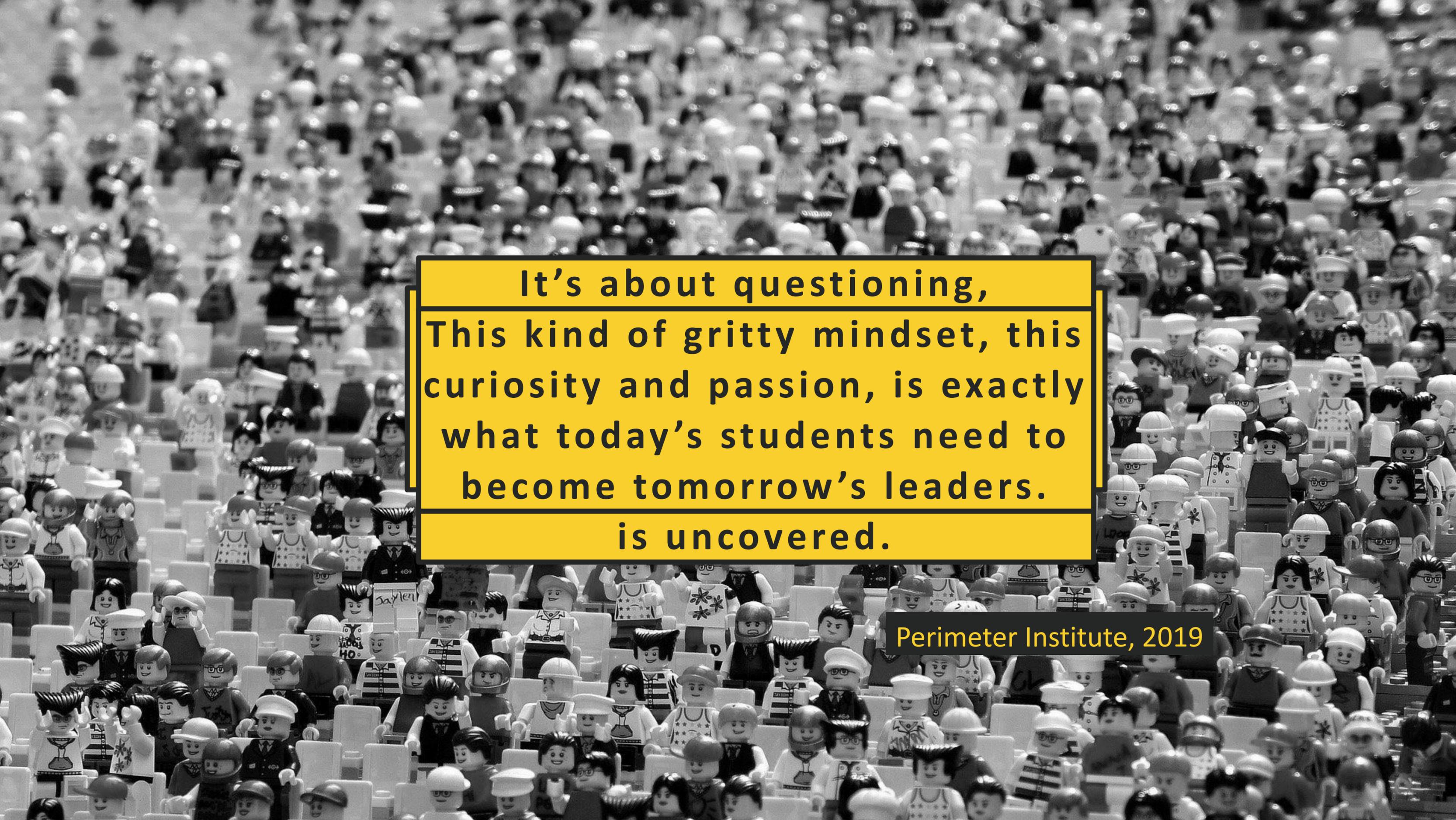
WHAT can we do and achieve?

How?

HOW do we continue?

**We are inextricably  
part of the world  
- and we have several  
kinds of  
responsibilities that  
follow from that.**

$$E = mc^2$$



**It's about questioning,  
This kind of gritty mindset, this  
curiosity and passion, is exactly  
what today's students need to  
become tomorrow's leaders.  
is uncovered.**

**Perimeter Institute, 2019**

# Why do we collaborate?

- pooling efforts in Einsteinian Physics education (research) -





**Change the  
emphasis of  
education in the  
whole world!**



**Let's us steer together to get it,  
led describe the suggestions of for  
physiologists,  
reasons for change,  
resources for change.**

“

---

**the world as it will be**

“NO SENSIBLE DECISION CAN BE MADE ANY LONGER WITHOUT TAKING INTO ACCOUNT NOT ONLY THE WORLD AS IT IS, BUT **THE WORLD AS IT WILL BE....**THIS, IN TURN, MEANS THAT OUR STATESMEN, OUR BUSINESSMEN, OUR EVERYMAN MUST TAKE ON A SCIENCE FICTIONAL WAY OF THINKING.”

- ISAAC ASIMOV -

---

”



**Bridging two things  
means a bond with  
both of them.**



# Why eper- COLLABORATION?

**We care about creating opportunities and promoting knowledge transfer.**

We want to find the most effective ways of working together within the physics community.

# PEOPLE WANT TO BECOME INVOLVED.



## IMPACT

By collaborating across departments, universities, and countries physics educators can **extend their reach** through extended networks and shared methods.



## PERSPECTIVES

Bringing together diverse perspectives allows utilizing **complimentary approaches** to pool educational efforts and expertise in physics education.



## FUNDING

The more research groups, departments, universities, associations,... involved, the more options there are to **apply for funding** and in-kind support.



# Why Einsteinian Physics Education RESEARCH?

**We care about educating future generations.**

We want to provide a modern and relevant educational experience to physics students.

# LET US INVEST IN RESEARCH-BASED EFFORTS.



## IMPACT

Educational research helps us develop means to **measure and increase impact** of educational programs and tailor them to the needs of different groups of students.



## QUALITY

Educational research provides insights into the **efficacy of instructional approaches** which, in turn, allows improving the quality of instruction.



## RELEVANCE

Educational research on **student attitudes, motivation, and identity development** feeds back into making physics education more relevant for diverse groups of learners.

A row of seven closed doors in a hallway, with the text overlaid in the center.

THE ONLY WAY FORWARD IS  
THROUGH SOMETHING WE'VE  
NEVER DONE.

# What can we do and achieve?

- EPER has had transformational power -



“

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Always remember!

COMMON SENSE IS THE  
COLLECTION OF PREJUDICES  
AQUIRED BY  
AGE EIGHTEEN.  
- ALBERT EINSTEIN

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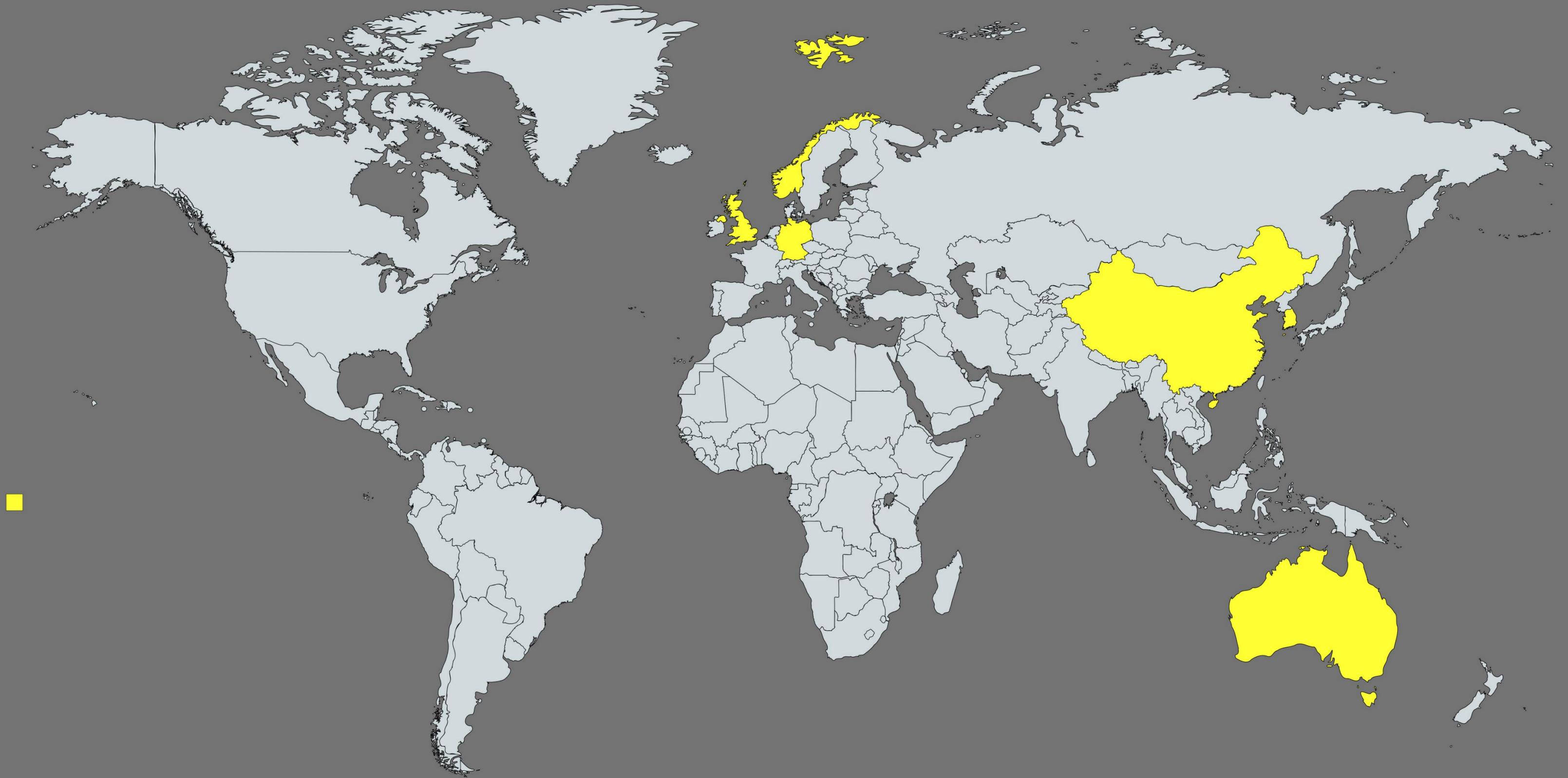
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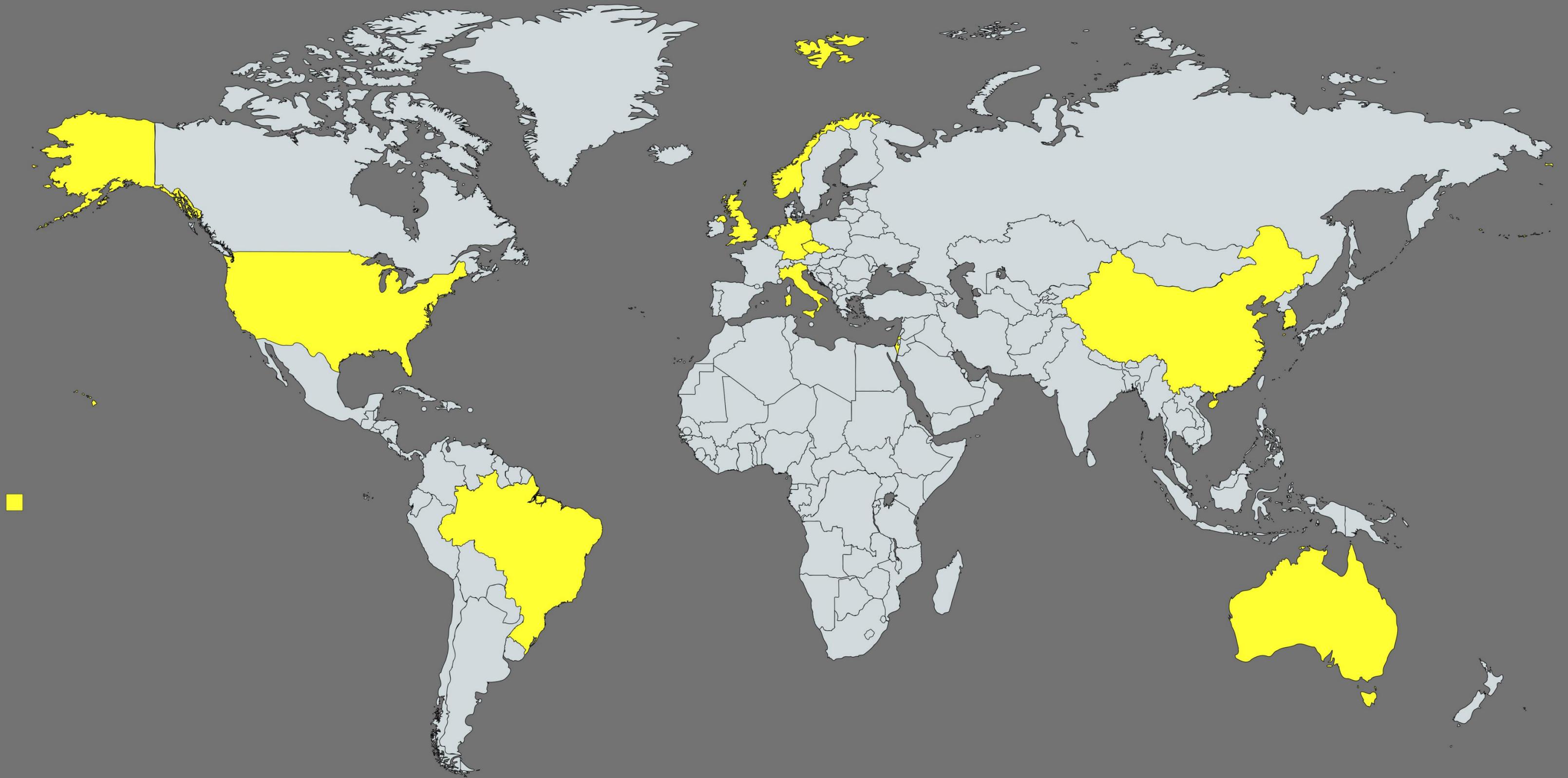
Our research groups have each pioneered different approaches to teaching and learning Einsteinian Physics.



**Every child has the right to share our best understanding of physical reality.**

We have encountered similar obstacles in implementing our approaches in schools and curricula.





# The Einsteinian Physics Education Research (EPER) Collaboration



2015  
INITIAL STEPS

On Wed, Dec 16, 2015 at 11:32 PM, Magdalena Kersting  
<[magdalena.kersting@fys.uio.no](mailto:magdalena.kersting@fys.uio.no)> wrote:

Dear Tejinder,

my name is Magdalena and I am a PhD student at the University of Oslo.  
I'm part of the research project ReleQuant which aims at developing new  
teaching resources for secondary school pupils.

In my PhD project I develop an online module on general relativity and I  
am interested in studying students' conceptual understanding of the  
abstract concepts as well as different teaching approaches that facilitate  
learning and understanding.

I came across the Science Education Enrichment Project and your  
project in particular sounds very interesting to me.

I would love to hear more about your research, and maybe we could  
even collaborate as our interests seem to have some overlap?

I am looking forward to hearing from you!

Best

Magdalena

Sorry for late answer.

I am glad our projects are like some degree. The main aim of my project is to  
present the thoughts of general relativity, special relativity and quantum physics  
at right on time years in school.

We built up a few exercises and had programs with Year 6, Year 9 and Year 11  
students. We got a positive results.

We additionally run some professional development programs and discovered  
teachers are likewise eager to present these thoughts in their classrooms on the  
off chance that they were prepared.

In my Ph.D, I am composing research papers on results got from the different  
programs.

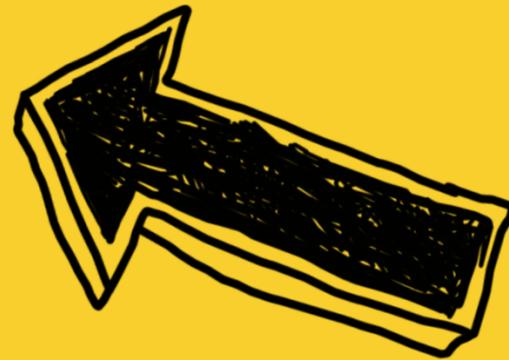
We are exceptionally glad to team up with you all.

Thanks,  
Tejinder Kaur  
PhD student  
School of Physics,  
The University of Western Australia  
M013, 35 Stirling Highway  
Crawley, WA 6009  
Australia

# The Einsteinian Physics Education Research (EPER) Collaboration

2015  
INITIAL STEPS

2016  
JOINT WORKSHOP  
IN PERTH





(picture via EPER collaboration, all rights reserved)



(picture via EPER collaboration, all rights reserved)

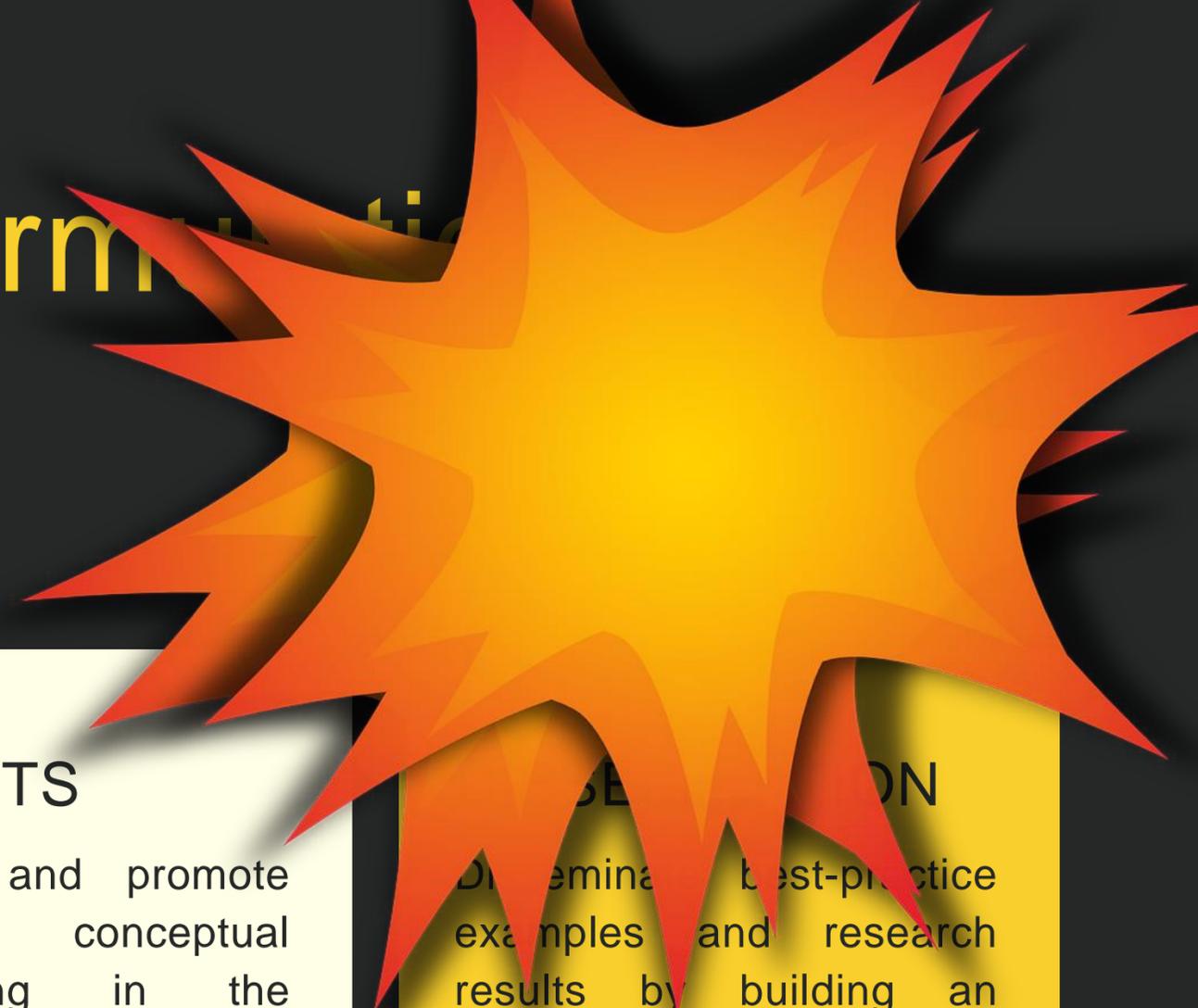


(picture via EPER collaboration, all rights reserved)



(picture via EPER collaboration, all rights reserved)

# The workshop led to the formation of shared goals:



## RESOURCES

Share existing Einsteinian Physics learning resources and develop novel learning resources for all levels of education.

## TEACHERS

Develop resources for teachers and run teacher professional development workshops.

## STUDENTS

Investigate and promote students' conceptual understanding in the learning domain of Einsteinian Physics.

## RESEARCH AND DISSEMINATION

Disseminate best-practice examples and research results by building an international research network.



One century after Albert Einstein revolutionized our world  
physicist Magdalena Kersting. Credits: Pixabay

**General Relativity - Why h  
should learn about Einste  
idea**

# Putting Einstein first: It's time to stop lying to our children about physics

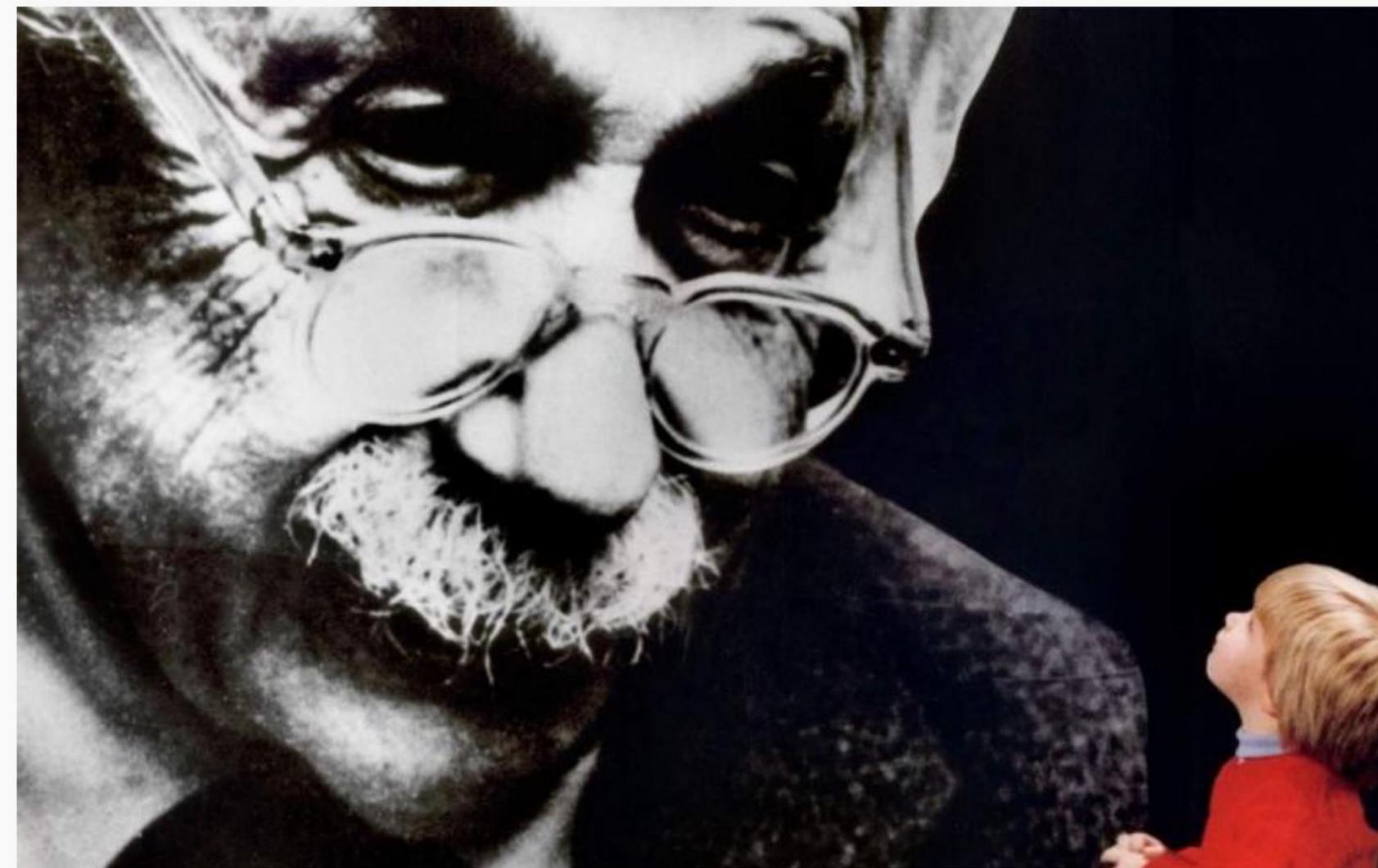
Share on Facebook Share on Twitter Print Email More

## OPINION

ABC Science By David Blair for Ockham's Razor

Updated 18 December 2019 at 1:13 pm

First posted 13 December 2019 at 5:27 am



told us that time depends on altitude and that matter can create holes where space and time come to an end.

## NAVIGATING FOUR DIMENSIONS

ue 27, Society & Education

MARKABLY SIMILAR TO THE GEOMETRY OF  
MAPS AS MODELS FOR TEACHING EINSTEIN'S  
RAL RELATIVITY.



David Blair  
Director, Australian International  
Gravitational Research Centre,  
University of Western Australia

Dr Karoline Henriksen  
Professor of physics education,  
University of Oslo



Martin Hendry  
Professor of Gravitational  
Astrophysics and Cosmology,  
University of Glasgow

# The Einsteinian Physics Education Research (EPER) Collaboration



A horizontal timeline with a black line and five black circular markers. The first marker is at the far left, the second is at the first year, the third is at the second year, the fourth is at the third year, and the fifth is at the far right.

2015  
INITIAL STEPS

2016  
JOINT WORKSHOP  
IN PERTH

2017  
CONFERENCES  
  
LEARNING  
RESOURCES  
  
RESEARCH  
PAPERS  
  
PROFESSIONAL  
DEVELOPMENT  
WORKSHOPS

# An International Research Collaboration in the Teaching and Learning of Einsteinian Physics

John Moschilla (1), Marjan Zadnik (1), David Blair (1), Warren Stannard (1), Magdalena Kersting (2)

1 Department of Physics, University of Western Australia

2 Department of Physics, University of Oslo, Norway

This presentation outlines the motivation, approach, and future directions of the International Einsteinian Physics Education Research (EPER) collaboration based on bridging research and practice by involving science educators, teachers and physicists. Facing the challenges of the 21<sup>st</sup> century, we must teach students our most contemporary scientific understanding of the Universe, while at the same time finding new ways of conducting physics education research on a global scale.

## Einstein in the classroom – an International approach

28 July 2017 | Source: Einstein in the classroom – an international approach

The Einsteinian Physics Education Research (EPER) collaboration met at the recent GIREP Physics Education conference in Dublin City University.



in DCU.

Paul Nugent with members of the EPER group

Their aim is to increase the awareness of Einsteinian physics in second-level schools in Europe. At present much of school physics is dominated by Newtonian physics which the group consider is at odds with the importance of Einstein's view of the universe, particularly so since the 2016 announcement of the first observation of gravitational waves, confirming Einstein's theory of general relativity.

# The Einsteinian Physics Education Research (EPER) Collaboration

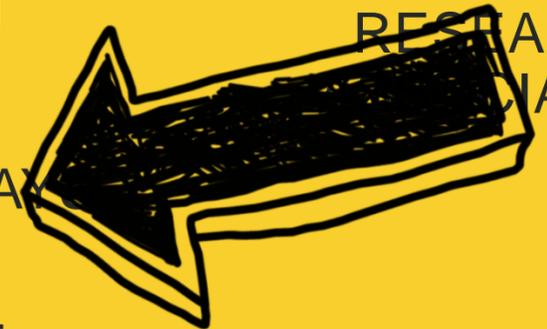
2015  
INITIAL STEPS

2016  
JOINT WORKSHOP  
IN PERTH

2017  
CONFERENCES  
  
LEARNING  
RESOURCES  
  
RESEARCH  
PAPERS  
  
PROFESSIONAL  
DEVELOPMENT  
WORKSHOPS

2018  
CONFERENCES  
  
RESEARCH  
PAPERS  
  
PROFESSIONAL  
DEVELOPMENT  
WORKSHOPS  
  
RESEARCH STAY  
  
JOINT SCHOOL  
PROGRAMS

NORWEGIAN  
RESEARCH  
COUNCIL  
&  
EUROPEAN  
SCIENCE  
EDUCATION  
RESEARCH  
ASSOCIATION





(pictures via Magdalena Kersting , all rights reserved)

# The Einsteinian Physics Education Research (EPER) Collaboration

2015

INITIAL STEPS

2016

JOINT WORKSHOP  
IN PERTH

2017

CONFERENCES

LEARNING  
RESOURCES

RESEARCH  
PAPERS

PROFESSIONAL  
DEVELOPMENT  
WORKSHOPS

2018

CONFERENCES

RESEARCH  
PAPERS

PROFESSIONAL  
DEVELOPMENT  
WORKSHOPS

RESEARCH STAYS

JOINT SCHOOL  
PROGRAMS

2019

INTERNATIONAL  
SEMINAR IN  
GERMANY

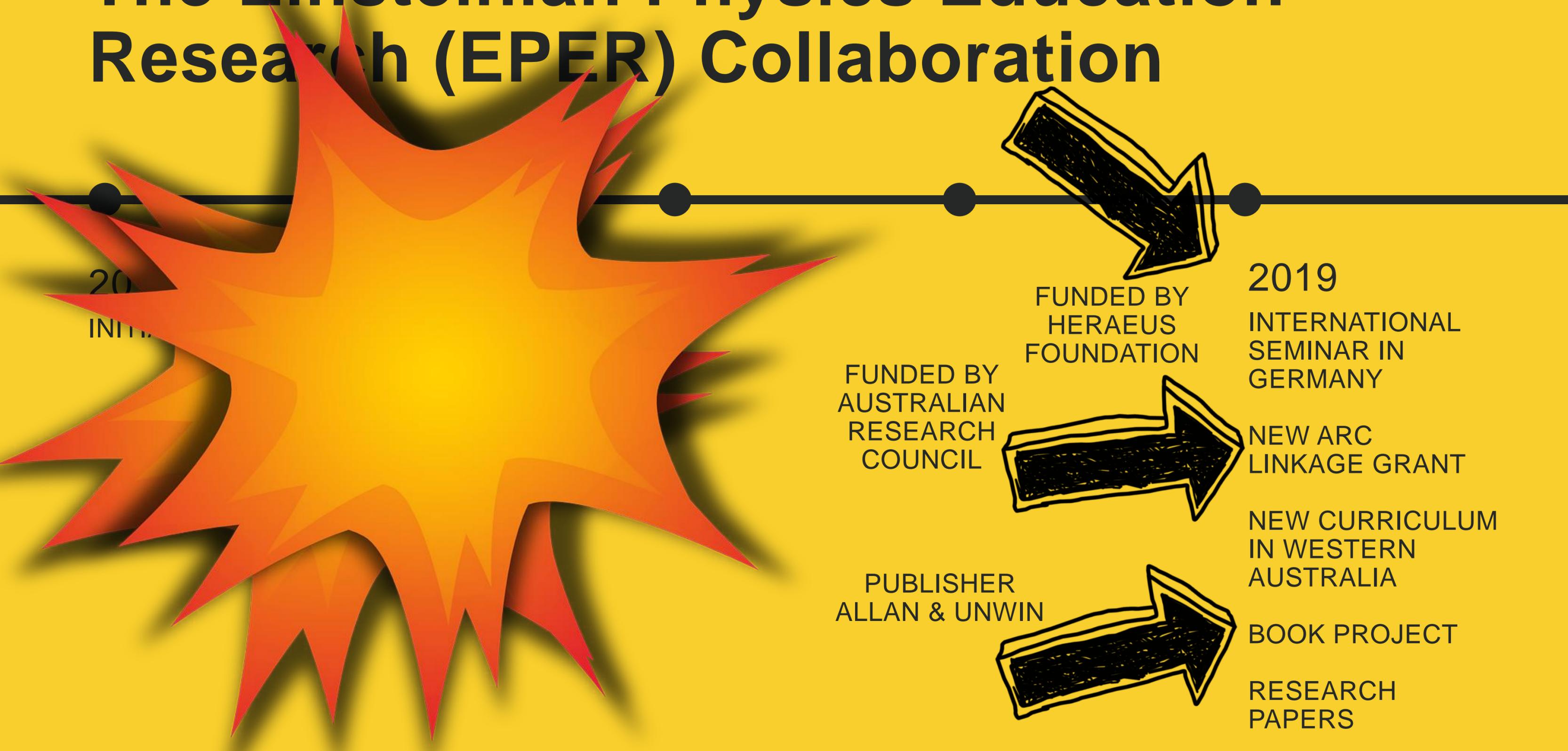
NEW ARC  
LINKAGE GRANT

NEW CURRICULUM  
IN WESTERN  
AUSTRALIA

BOOK PROJECT

RESEARCH  
PAPERS

# The Einsteinian Physics Education Research (EPER) Collaboration



20  
INITI

FUNDED BY  
AUSTRALIAN  
RESEARCH  
COUNCIL

FUNDED BY  
HERAEUS  
FOUNDATION

PUBLISHER  
ALLAN & UNWIN

2019

INTERNATIONAL  
SEMINAR IN  
GERMANY

NEW ARC  
LINKAGE GRANT

NEW CURRICULUM  
IN WESTERN  
AUSTRALIA

BOOK PROJECT

RESEARCH  
PAPERS

# Teaching Relativity

Education Research on General Relativity



## 690. WE-Heraeus-Seminar: General Relativity as a Challenge

This seminar was funded by the [Wilhelm and Else Heraeus Foundation](#). It took place 10-15 Feb 2019.

[Scope of the seminar](#)

[Program with abstracts of talks and posters](#)

[Slides of the talks \(password required\)](#)

**Poster prizes** were awarded to: Michael Schultz, Roberto Salgado, Markus Pössel, Shachar



Photo from left to right: Lotze (Jury), North, Reiber, Boubilil, Pössel, Salgado, Schultz,



# UWA awarded \$898,560 to teach Einstein's physics in schools

Tuesday, 19 March 2019

Researchers at The University of Western Australia have been awarded \$898,560 for a ground-breaking international research project to teach Einstein's theories of space, time, matter, light and gravity through primary and secondary school.

Federal Minister for Education Dan Tehan today announced more than \$5.7 million in funding for university research projects through the Australian Research Council (ARC).

UWA's project will be led by internationally recognised physicist Emeritus Professor David Blair who played a key role in the discovery of gravitational waves. Professor Blair is outreach program leader at the [Centre of Excellence for Gravitational Wave Discovery \(OzGrav-UWA\)](#).



Professor Blair said it was hoped the project would mobilise a huge team of physicists and educators at UWA, Curtin University, Australian National University, as well as five international universities, and the WA Department of Education, the Science Teachers Association, the Association of Independent Schools, Mt Lawley Senior High School and the Gravity Discovery Centre.

"We've already proved that kids love Einstein's physics and are keen to learn it. Now we can work on creating a full school curriculum that teaches children about the nature of space, time and gravity right from year three all the way through their schooling," he said.

Following a previous project that showed that it was possible and beneficial to teach the modern Einsteinian paradigm of space, time, matter, light and gravity to students as young as eight years old, this project aims to test and evaluate a seamless progression of learning modern physics through primary and secondary school.

It will sequence, integrate and test research-informed teaching and learning materials, and assessment instruments developed through a seven-nation collaboration involving the US, Norway, Germany, Scotland, South Korea and China.

## UWA awarded \$898,560 to teach Einstein's physics in

Professor Blair said it was hoped the project would mobilise a huge team of physicists and educators at UWA, Curtin University, Australian National University, as well as five international universities, and the WA Department of Education, the Science Teachers Association, the Association of Independent Schools, Mt Lawley Senior High School and the Gravity Discovery Centre.

for a ground-breaking international research project to teach Einstein's theories of space, time, matter, light and gravity through primary and secondary school.



“We’ve already proved that kids love Einstein’s physics and are keen to learn it. Now we can work on creating a full school curriculum that teaches children about the nature of space, time and gravity right from year three all the way through their schooling,” he said.

David Blair who played a key role in the discovery of gravitational waves. Professor Blair is outreach program leader at the [Centre of Excellence for Gravitational Wave](#)



Research across 24 schools will be reviewed by a panel comprising members of professional organisations and curriculum authorities, and learning resources will be widely disseminated, with view to worldwide introduction of Einsteinian science at school.

“We’ve already proved that kids love Einstein’s physics and are keen to learn it. Now we can work on creating a full

Partner organisations are providing \$560,000 cash and \$4.38 million in-kind and include WA’s Gravity Discovery Centre Foundation, Department of Education, Association of Independent Schools of WA, Science Teachers Association of WA, Mount Lawley Senior High School, ANU, University of Oslo, Seoul National University, University of Hildesheim in Germany, University of Glasgow and Beijing Normal University.

It will sequence, integrate and test research-informed teaching and learning materials, and assessment instruments developed through a seven-nation collaboration involving the US, Norway, Germany, Scotland, South Korea and China.



## CONTRIBUTOR BRIEF

### TEACHING EINSTEINIAN PHYSICS IN SCHOOLS

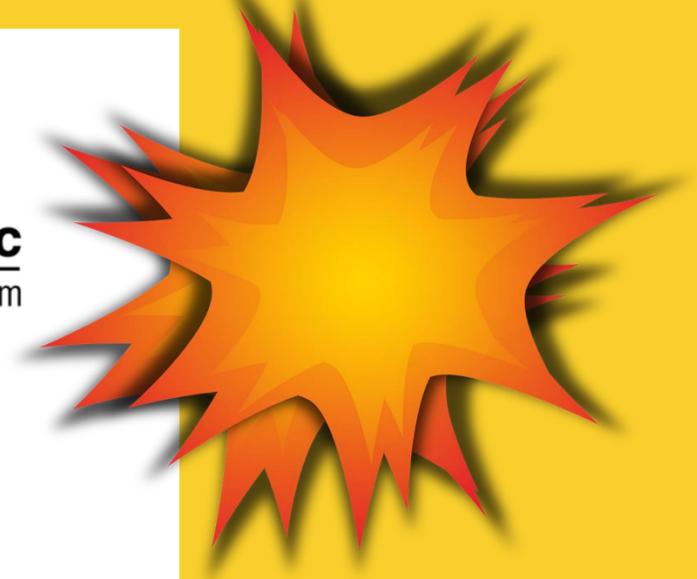
Edited by David Blair, Magdalena Kersting

#### *Readership*

This book is intended as a professional reference title for teachers in schools and for pre-service teacher education students, including those preparing to teach in primary schools.

While you can assume that secondary science teachers have studied physics to at least the final year of high school, it is likely that primary school teachers did not study physics beyond middle high school. While we expect your chapters to be evidence-based, please take this into account in your writing. Write in simple, direct prose and provide explanations of physics concepts that some readers may not understand.

This book is intended for an international readership. Please provide any additional details an international reader needs to understand your examples and references to your country's school curriculum etc.



## Einsteinian Physics in the Classroom: Integrating Physical and Digital Learning Resources in the Context of an International Research Collaboration

Rahul Choudhary<sup>\*,§</sup>, Ute Kraus<sup>†</sup>, Magdalena Kersting<sup>‡</sup>,  
David Blair<sup>\*</sup>, Corvin Zahn<sup>†</sup> and Marjan Zadnik<sup>\*</sup>  
*\*OzGrav-UWA, Department of Physics,  
The University of Western Australia, WA 6009, Australia,  
†University of Hildesheim, Germany,  
‡University of Oslo, Norway  
§rahul.choudhary@research.uwa.edu.au*

Richard Meagher  
*Mount Lawley Senior High School, Australia*

Received October 30, 2019; Revised November 18, 2019

This study reports on a pilot program conducted by members of the international Einsteinian Physics Education Research (EPER) Collaboration that aims to pool and combine innovative learning approaches in Einsteinian Physics. The collaboration also aims to disseminate learning resources and research results across a range of countries. In this study, we describe an integrated pilot programme that combines physical models and digital resources to explore secondary school students' (Grade 10, 15 years old) conceptual understanding in the learning domain of

**How** do we continue from here ?

- running full speed into a great future of modern physics education -



“

---

educate future generations

EINSTEIN'S IDEAS WILL SEEM EASIER  
TO GENERATIONS WHICH GROW UP  
WITH THEM.

- Bertrand Russell -

---

”

# IMPACT IN PHYSICS EDUCATION

## PRACTICE

We have worked with teachers and students around the world to find instructional approaches that work in the classroom practice.

## RESEARCH

We have pushed the boundaries of modern physics education research and continue to develop and publish new frameworks, models, and empirical results.

## PARADIGM CHANGE

Paradigmatic changes do not happen over night; we take the next steps via curriculum development and the compilation of a reference book.





# What obstacles do we face?

- fear that students are not able to learn Einsteinian concepts
- lack of material for classes and lectures
- lack of confidence with new content
- lack of confidence in trying new methods
- lack of background in the use of active learning approaches
- ...



# How to face obstacles ?

## ESTABLISH UNDERSTANDING

- opening minds to concepts of Einsteinian Physics
- building conceptual and qualitative understanding
- talking and reasoning like physicists

## INSTIL APPRECIATION

- nature of science and scientific method
- role of fundamental research
- link between science and technology
- give students tools to make decisions

## BUILD CONFIDENCE & MOTIVATION

- science is for everyone
- train the teacher
- innovative models and pedagogical approaches

# Lessons worth sharing

## INVEST IN RESEARCH & POSTGRADUATE TRAINING

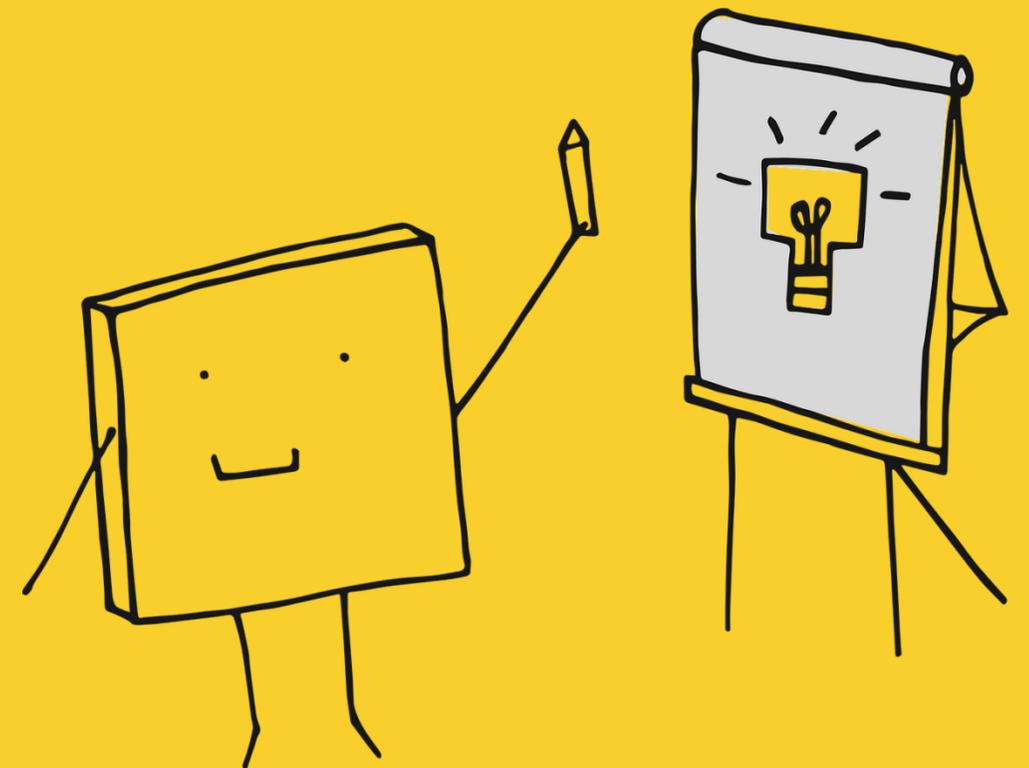
PhD-students have been a driving force in the EPER collaboration.

## REACH OUT TO PRACTITIONERS

People are keen to be involved and to work towards a shared goal.

## KEEP UP THE MOMENT

Achieve big goals by harnessing the power of small steps.

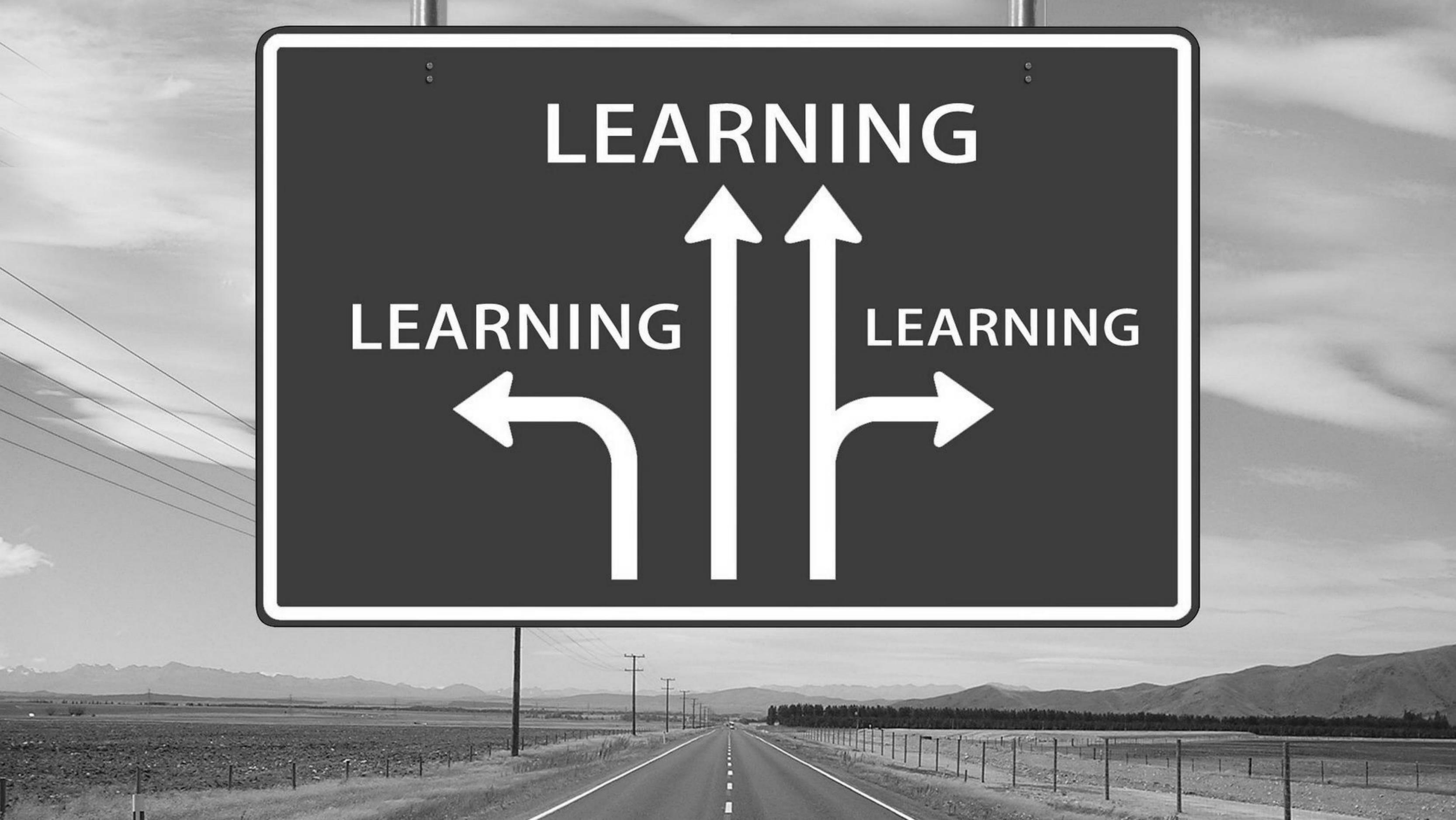
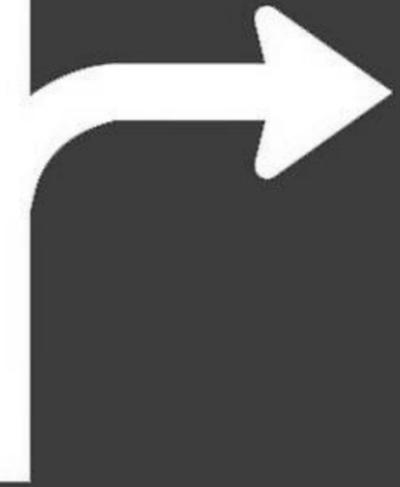




LEARNING

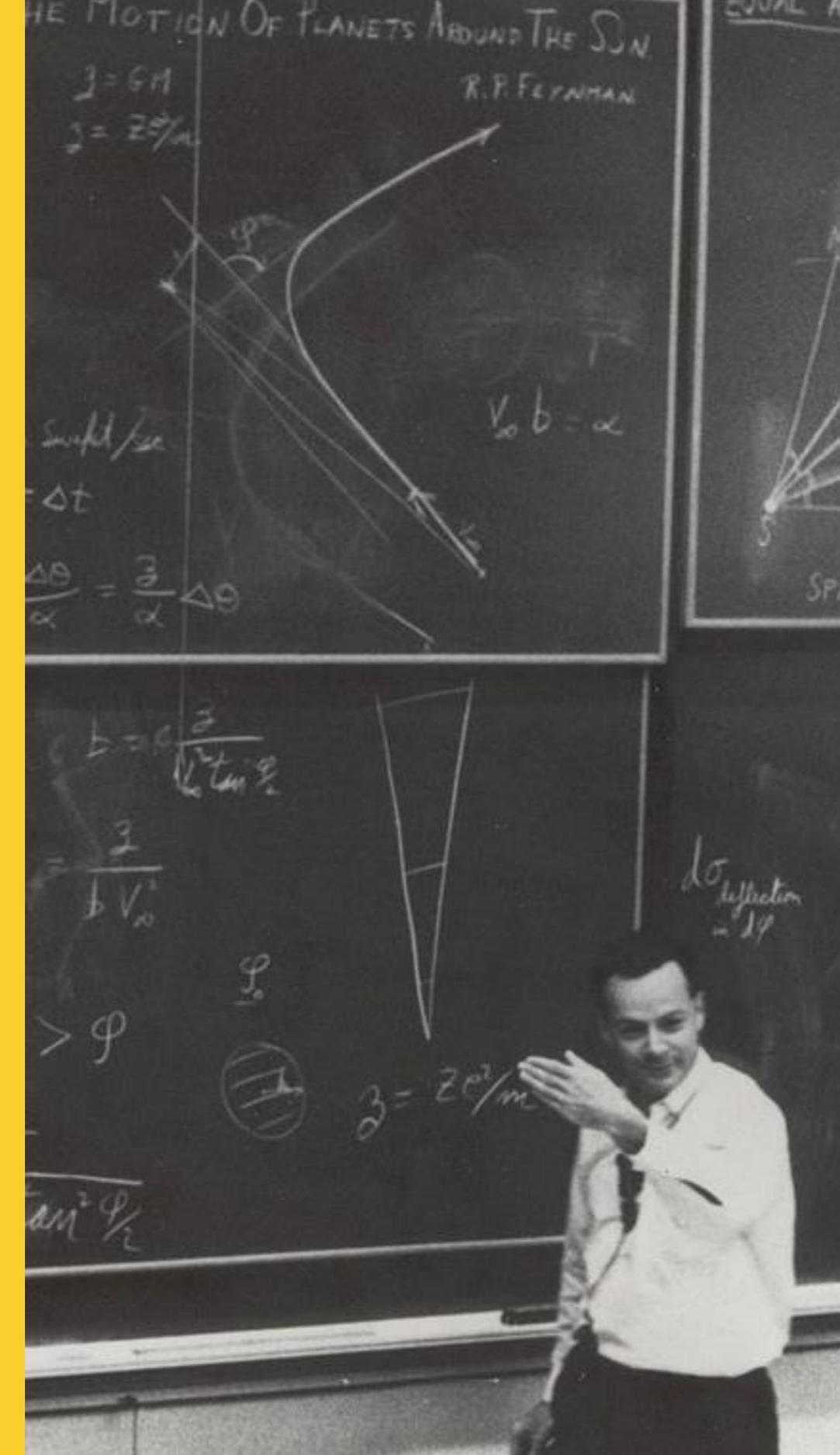
LEARNING

LEARNING



# There can be no educational development without teacher development.

Studies of teacher perspectives and their professional development will be an important contribution to firmly establish Einsteinian Physics.



# Finding the balance between dialogic and authoritative modes of instruction is tricky.

Future research could look more specifically at interactions between teachers and students to realize the full potential of Einsteinian Physics.



**We have to move beyond case-studies  
and explorative research.**

Future projects should involve greater student populations and  
different national contexts.

The creation of a concept inventory in general relativity would be  
an important contribution.



# Emerging technologies present exciting opportunities & considerable challenges.

Letting students experience Einsteinian phenomena through virtual and augmented reality presents a great vision for physics education.



# Summary

Why?

We want to provide a modern and relevant educational experience to physics students.

What?

The EPER collaboration has had transformational power.

How?

We are running full speed into a great future of modern physics education.



**Following up on our 1<sup>st</sup> international gravitational waves outreach group (iGrav) meeting in Valencia in 2019, we continue to gather enthusiasts and advocates for gravitational wave education and outreach.**



# Want to learn more?

## EINSTEINIAN PHYSICS

[www.einsteinianphysics.com](http://www.einsteinianphysics.com)

<https://www.ozgrav.org/education.html>

<https://teaching-relativity.org>

## HUB OF RESOURCES

[www.magdalenakersting.com](http://www.magdalenakersting.com)

## GET IN TOUCH

[magdalena.kersting@fys.uio.no](mailto:magdalena.kersting@fys.uio.no)

@MagdaKersting



# References

## PICTURES & ILLUSTRATIONS

all pictures are creative commons CC0 if not noted otherwise

## ARTICLES (slide 33 & 35)

<https://theconversation.com/why-dont-we-teach-einsteins-theories-in-school-69991>

<http://www.lateralmag.com/articles/issue-27/navigating-four-dimensions>

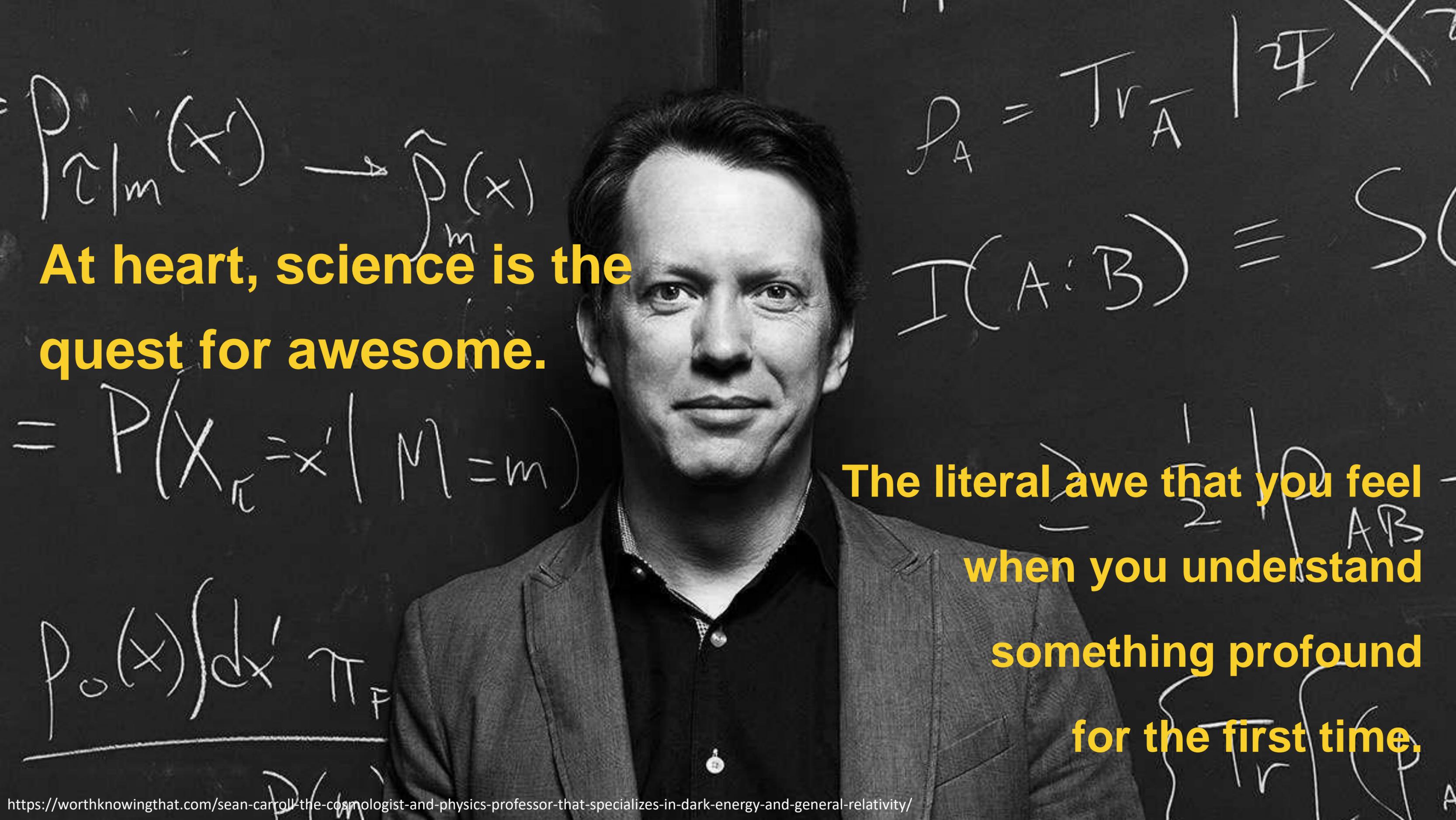
<https://titan.uio.no/node/2671>

[http://www.iopireland.org/news/17/jul/page\\_69875.html](http://www.iopireland.org/news/17/jul/page_69875.html)

<https://www.abc.net.au/news/science/2019-12-13/time-to-stop-lying-to-our-children-about-physics/11789858>

## CONTENT (slide 49)

the list on slide 45 is adapted from the talk „Time for Changing Paradigms in Science and Education“ held by David Treagust at the Heraeus seminar „General Relativity as a Challenge for Physics Education“ in Bad Honeff 2019



$$P_{\hat{\pi}|m}(x) \rightarrow \hat{P}_m(x)$$

**At heart, science is the quest for awesome.**

$$= P(X_{\pi} = x' | M = m)$$

$$\frac{P_0(x) \int dx' \pi_F}{P(m)}$$

$$P_A = \text{Tr} \bar{A} | \Psi \rangle \langle \Psi |$$
$$I(A:B) \equiv S(A) + S(B) - S(A:B)$$

**The literal awe that you feel when you understand something profound for the first time.**

**Physics education  
sits at the  
crossroads of  
disciplines.**



Do not stand on the inside of what  
is possible and push.  
Imagine what is outside of what  
we deem possible and pull  
towards this vision of what is  
better.

- Frank Chipero -

# The Einsteinian Physics Education Reserach (EPER) Collaboration

wants to teach students our most contemporary scientific understanding of the universe,



(picture via EPER collaboration, all rights reserved)



(picture via Einstein First, all rights reserved)

while finding new ways of conducting physics education research on a global scale.



David Blair <david.blair@uwa.edu.au>  
Tue 2016-02-23 11:40

Mark as unread

To: Tejinder Kaur <tkaur868@gmail.com>; Magdalena Kersting;

You replied on 2016-03-03 16:00.

Bing Maps

Action Items

Hi Magdalena,

We would be very interested in working together with your group. I think it is important that the project leaders agree about this, and that we make a plan. Funding is always difficult for us, but we do have some funds that could be used.

It could be great to plan two workshops, one in Oslo and one in Perth, and to try to include other people as well. Alternatively we could have a small group to group meeting.

Please discuss what is possible and let us know what you decide. Perhaps we could have a Skype discussion for some joint planning.

best regards

david

## International Workshop on the Teaching and Learning Einsteinian Physics in the Era of Gravitational Astronomy



28 November - 2 December 2016,  
Gravity Discovery Centre, Yeal and Curtin University, Bentley, Western Australia.