Submission from the University of Western Australia Einstein-First Project to the Inquiry into the response of Western Australian schools to climate change

Education and Health Standing Committee

Terms of reference

The Education and Health Standing Committee will inquire into the response of Western Australian schools to climate change. In particular, the inquiry will consider:

1. The co-benefits of climate action in schools
2. Climate change mitigation and adaptation actions currently being undertaken in schools, and the benefits they are achieving
3. Barriers that schools encounter in undertaking climate action and how these can be addressed
4. What more can be done to support schools to respond to climate change.

Introduction

Einstein-First (EF) is a UWA Physics Department education initiative led by distinguished physicist Emeritus Professor David Blair to address the critical decline in teenage student attitudes to Science, Technology, Engineering and Mathematics (STEM). Our activity-based curriculum and professional learning program enables all teachers, regardless of their background, to inspire their students about science through fun, activity-based learning of modern physical science concepts. Young people perceive science to be old and boring because of the mismatch between the modern science they learn informally through the media and the outdated 19th century science they learn up to Year 10.

The EF Project is part of an Australian and international collaboration focusing on introducing Einsteinian Physics into Years 3 to 10. The project is funded by the Australian Research Council with support from the WA Education Department, Association of Independent Schools WA and Science Teachers Association of WA. Additional private sector funding is currently being sought to help with the production of high-quality online professional learning resources. We are in the early stages of our development and research, with a range of classes trialling our materials and several PhD students working on the research involved in this project.

Over 10 years of testing and trials conducted by the UWA team, and now replicated internationally, the EF team has demonstrated that primary school children can comprehend the key scientific concepts needed to understand climate. Secondly through the EF approach based on using models and activities to teach modern concepts, students are highly motivated and, as emphasised by teachers trialling the program: "The notable thing about the Einsteinian physics lessons is that students are fully engaged, disruption is rare, and students with learning difficulties are practically indistinguishable from mainstream students. Girls benefit especially from the way the program is presented with group learning and activities. It is not intimidating, and teachers like myself enjoy the program because it makes my teaching feel much more worthwhile." (Stated by a Year 8 teacher in a Perth school.)

A feature of the Einstein-First initiative is that an integrated Climate Science and Sustainable Energy program will be taught in Year 6. The lessons build on concepts of atoms and

molecules, heat, forces and light as photons introduced in the Year 3, 4 and 5 chemical and physical sciences topics. Our modern understanding of these concepts is generally not introduced into primary school even though these concepts are essential to understanding climate science and alternative energy production. These ideas will be further developed in Years 8, 9 and 10.

Addressing the Terms of Reference

1. *The co-benefits of climate action in schools*

We believe that we owe it to all students to teach them the basic science behind environmental sustainability including climate change and energy production, storage and transmission. All students should leave Year 10, the final year of compulsory science, knowing that the choices they and their families make now will influence what happens in the future. Science has helped us understand how emission of carbon dioxide and other greenhouse gases from human activity have caused global warming, and this knowledge will help lead students to appreciate that they can influence how they use energy in the future. Knowledge and understanding gained has the potential to increase students' own agency relating to energy choices and decrease their anxiety related to climate change, reported in a major international study that is discussed later.

If lessons are structured to share with parent and grandparents, then it is likely there will be a positive flow-on effect of students' school learning to the wider community.

The collaborative work being conducted in schools by energy utilities Synergy, Horizon and Western Power has helped raise awareness of the need for the whole community to transition to green energy sources and provide concrete ways of achieving this at the personal, family and community levels.

2. *Climate change mitigation and adaptation actions currently being undertaken in schools, and the benefits they are achieving*

We understand that many schools have a strong sustainability focus through lessons that integrate knowledge from different learning areas and across the science disciplines. Students learn that science provides the basis for decision-making in many areas of society and that these decisions impact climate. Students also learn the importance of using science to predict effects of human and other activity and to develop management plans or alternative technologies that minimise these effects.

However, despite many schools having excellent programs, there are many others where sustainability programs could be significantly strengthened if the barriers in undertaking climate action were addressed and resolved.

3. *Barriers schools encounter in undertaking climate action and how these can be addressed*

Barriers to the introduction of climate action in schools include:

Availability of high-quality curriculum resources

Despite there being many good ideas for teaching aspects of climate science and sustainable energy available to teachers through the internet, most teachers do not have the time or experience to research and trial these resources with their classes. Having a single resource available will be much appreciated and extremely helpful for teachers.

Science background and expertise of teachers, particularly in primary schools

Our experience with the EF program is that many teachers of science, especially in primary schools, have never been taught the science required for them to introduce the basic science concepts behind climate change and sustainable energy production to their students. These teachers would be unable to confidently explain how the Earth heats up during the day and cools down at night, why average temperatures are increasing year-on-year, causing the climate to change, how tiny amounts of CO_2 and other greenhouse gases trap heat, how solar panels produce electricity and how hydrogen fuel cells work. Professional learning resources for teachers being produced by the Einstein-First program to support the Einstein-First lessons will help address these gaps in teachers' knowledge.

Class time to teach about climate science in primary schools

Despite the School Curriculum and Standards Authority advice to schools that science should be taught for two hours per week in Kindergarten to Year 6[1], the actual time allocated in almost all Primary schools is typically an hour per week or less. Now is the time to re-visit this important issue at the school policy level. It is not appropriate for the State Curriculum Authority to issue guidelines which are then ignored by school principals, teachers and systems.

4. Additional support for schools to respond to climate change.

An important feature of the Einstein-First initiative is that an integrated Climate Science and Sustainable Energy program will be taught in Year 6 in hands-on, fun-filled interactive ways. The lessons will build on concepts introduced in the Years 3, 4 and 5 chemical and physical sciences topics of heat, forces and light introducing atoms and molecules, photons and phonons that are not currently introduced into primary school. These ideas will then be further developed in Years 8, 9 and 10.

Climate change impact on young people's mental health and wellbeing

In the largest international study of its kind led by the University of Bath[2],the results dramatically showed that "climate anxiety affects the daily life and functioning of nearly half of children and young people surveyed globally". The report went on to state:

> "Factors known to protect against mental health problems include psychosocial resources, coping skills, and 'agency' to address and mitigate stressors. In the context of climate anxiety this would relate to having one's feelings and views heard, validated, respected, and acted upon, particularly by those in positions of power and upon whom we are dependent, accompanied by collective pro-environmental actions. However, this survey demonstrates that large numbers of young people globally regard governments as failing to acknowledge or act on the crisis in a coherent, urgent way, or respond to their alarm. This is experienced as betrayal and abandonment, not just of the individual but of young people and future generations generally."

The approaches that will be taken in the lessons being developed by the EF team are consistent with the proposed protective factors above which include engaging students in the

[1] See the notional teaching time allocated to each learning area guidelines at: https://k10outline.scsa.wa.edu.au/__data/assets/pdf_file/0018/321714/Advice-on-Time-Allocation-2016.pdf)

[2] Retrieved from: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3918955. Posted: 7 Sep 2021. Elizabeth Marks et.al., University of Bath. *Young people's voices on climate anxiety, government betrayal and moral injury: a global phenomenon*.

learning activities and actively participating in individual and community action. Students work with full-sized solar panels and use the electricity generated from these to power full-scale devices such as 12-volt drills, water pumps, globes etc. and illustrate the many useful energy transfer and transformation processes. In addition, students will prepare an activity and presentation on Climate Change to share with younger children in their school (Kids teaching Kids) and to their parents and grandparents. Students will be encouraged to be involved in the decision-making about energy use at school and in their homes. Schools currently do this very well through the excellent schools 'Waste Wise' program. Similar approaches will be adopted by having students actively monitor their school and home energy use. This power sharing and open discussions could ameliorate the negative mental health effects demonstrated in the Bath research.

Brief description of the Einstein-First programme

The Einstein-First project is motivated by the current drastic decline in teenage attitudes to STEM. Young people perceive science to be old and boring because of the mismatch between the modern science they learn informally through the media and the outdated 19th century science learned before Year 10. Equally disturbing is the lack of general understanding in the community about key science-based issues including climate change and the need to move away from a carbon-based energy economy. If Australia is to thrive into the future, we need all citizens to be highly science and technology literate. The most efficient and effective way to achieve this is through what science students learn and the attitudes and dispositions they develop throughout their compulsory years of schooling.

Einstein-First addresses the foundational cause of the STEM decline. Our curriculum introduces modern concepts from an early age using toys, songs, models and games. A seamless learning progression enables all students by Year 10 to have a basic understanding of the science that underpins our lives.

The Project includes Climate Change into the lessons being developed for schools. We strongly support Climate Change education. Recently we became aware the University of Bath report which details an existential threat to ignoring or failing to take significant action on Climate Change, including Climate Change education.

The Einstein-First project is developing integrated Climate Science and Sustainable Energy programs for Year 6 that are concrete, fun and interactive. The lessons will build on concepts introduced in EF lessons from earlier years within chemical and physical sciences topics, including atoms and molecules, photons and phonons that are not currently in primary school programs. These ideas will then be further developed in Years 8, 9 and 10.

We are applying for private sector grants to enable online professional learning programs to support teachers with the introduction and teaching of these materials. We owe it to all students to give them a basic understanding of the science behind environmental sustainability generally, and climate change and energy production, storage and transmission specifically. All students should leave Year 10, the final year of compulsory science study, knowing that the choices they and their families make now will influence what happens in the future.

The focus of our discussion should be on ensuring we all empower young people by increasing their agency through the development of a basic knowledge and understanding of climate science, particularly the role greenhouse gases play in trapping heat energy within the atmosphere and what needs to be done to harness 'green energy sources' and as far as is possible to eliminate the production of energy from fossil fuels.

EF Climate Change Forum for development of Year 6 lessons

To start the lesson planning process for Year 6, a joint UWA Einstein-First Project and STAWA professional learning program for primary school teachers of science was held on 8 September 2021. The program included talks by Emeritus Professor David Blair, 2020 recipient of the Prime Minister's Science Prize and leader of the Einstein-First Project and Professor Malcolm McCulloch from the Marine Institute, UWA.

Part of the Forum was used to find out how much Climate Change is being taught in schools, what resources are used, suggestions for resources and advice for the Einstein-First team in approaches to teaching Climate Change. This was very timely in view of the Parliamentary Inquiry.

We surveyed the Primary School teachers who attended this professional learning program and asked: "At your school, what is currently being taught to students about climate change and global warming?" Generally, the responses indicated that teachers approached the teaching of climate change in an *ad hoc* and opportunistic way if they taught it at all. Some of the responses from a group of 20 teachers are provided in Attachment 1.

Proposal for Einstein-First Year 6 Climate Change Lessons

The Einstein-First team recommends that all Year 6 students in WA should be introduced to the science of climate; evidence, explanation and consequences of global warming; and introduction to sustainable energy futures. We plan to use information gained from our Climate Change forum, the report that will derive from this Review, and the range of teaching ideas developed by the team and available on the internet.

Lessons are currently being drafted in modular form in consultation with a small group of teacher volunteers. Attachment 2 (pages 9-11) provides an overview of the three modules that will be developed: Science of Climate; Global warming and Climate Change and Alternative Energy Futures. The first module introduces students to the science of climate. Students apply their introductory knowledge of atoms, molecules, photons, heat, energy and energy transfer to develop an introductory understanding of the part that heat, the atmosphere and oceans play in determining our climate. In the second module, students learn that almost all energy on Earth comes as photons from the Sun, how these interact with the land, oceans and air to trap and store heat, and how the heat moves around, the evidence of increased global warming and what needs to be done to decrease the impact of the so-called greenhouse gases. Module 3 provides an opportunity for students to explore alternative energy futures through many hands-on activities. The list of lessons or topics and a brief description of what students will learn is provided in Attachment 2.

The lessons and ideas have been developed so they are consistent with the current Western Australian Science curriculum for Year 6. However, as the context for the lessons relates specifically to climate science, global warming and climate change, and alternative energy, most teachers of Year 6 science in primary schools will need support in developing the knowledge, skills and confidence to teach these lessons.

The Einstein-First program will provide a curriculum resource that will help teachers introduce and teach these ideas to Year 6 students. They can then build on the ideas introduced in primary school in Years 8, 9 and 10.

Year 8, 9 and 10 Einstein-First Modules

A separate set of lessons is being developed, trialled and researched for Year 8, which again addresses aspects of Climate Change and renewable energy in a topic on Energy.

The Year 8 program builds on what students learnt about climate science in Year 6. They are introduced to our current understanding of energy which includes our modern understanding of light (photons), electrons, and phonons (sound and heat). Activities involve student doing a range of activities using commercial scale solar panels and 12-volt devices such as electric drills to develop an intuitive understanding of and measure energy, work and power. Students will leave Year 8 with the modern physical conceptual foundations that prepares them for further development of modern understanding of science in high school, further training and university.

In Year 9, students learn how energy transfer through different mediums can be explained using wave and particle models. They explore how and why the movement of energy varies according to the medium through which it is transferred, discuss wave and particle models and how they are useful for understanding energy transfer. Further, students will investigate the transfer of heat, and identifying situations in which each occurs and identify factors that affect the transfer of energy through an electric circuit. At this point, the Year 9 Einstein-First module focuses mostly on energy transfer and the wave particle model. There is definitely scope to include applications of these concepts to climate science, and we will collaborate with teachers to explore how this can best be achieved in the context of contemporary physics and chemistry understandings.

The Year 10 curriculum requires teachers to teach students about global systems, including the carbon cycle, rely on interactions involving the biosphere, lithosphere, hydrosphere and atmosphere. This content includes: investigating how human activity affects global systems; modelling a cycle, such as the water, carbon, nitrogen or phosphorus cycle within the biosphere; explaining the causes and effects of the greenhouse effect; and investigating the effect of climate change on sea levels and biodiversity. The topics of Global systems also suggests investigating currently occurring changes to permafrost and sea ice and the impacts of these changes; examining the factors that drive the deep ocean currents, their role in regulating global climate, and their effects on marine life and considering the long-term effects of loss of biodiversity.

We will be surprised if many secondary schools do not already have excellent programs that teach students these ideas in the climate science and alternative energy futures contexts. The Einstein-First project plans to hold a secondary climate science forum in the first half of 2022. This forum will provide the basis of a program that schools can use to build on to their existing programs or adopted to teach these key ideas if their programs do not currently explain these concepts using modern physical science concepts.

Concluding comment

Need for quality curriculum and teacher professional development

Climate action is based on firstly understanding climate change. Without understanding the first principles of climate science outlined above, essential and critical action would be less effective. Comprehensive climate change curriculum and materials for schools are currently being developed within the Einstein-First project. Teacher professional learning will be essential to the uptake and quality implementation of these resources.

Wider circle of decision-making

A whole education community, including students, teachers, parents, business and governments need to be included in a widening circle of responsibility. The students are the least powerful in this circle and climate action in schools should, as needed, draw on adults who are in positions to make positive and urgent decisions about climate action.

Best practice school climate action would include students representing these issues themselves and participating in high-level decision-making, having their voices heard and acknowledged within local, state and national decisions and action.

Public hearings

If there are public hearings, then I would be pleased to attend with one or two members of the Team to discuss our response with the Committee.

Emeritus Professor David Blair on behalf of the Einstein-First Team
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Attachment 1

Teacher feedback from the Climate Change Forum

- “I briefly talked about climate change.”
- “The concept of climate science is not expressed directly in the curriculum, but … I know I have needed to touch on basic concepts about climate change and greenhouse effect.”
- “We don't currently have any programs on offer but are looking to create some.”
- “My students hit my class in Year 6 with little, to no, understanding about climate change and global warming.”
- “Through an inquiry approach e.g. natural disasters. Not explicitly taught.”
- “Sustainability and negative impact of fossil fuels.”
- “Low socio-economic school that concentrates on the three Rs of old. I ALWAYS reference global warming in the context of their Science curriculum.
- “Nothing specifically in a unit of work form”
- “No specific content… focus is on Sustainability.”

One exception was a teacher who contributed this:

- “In the Earth and Space Science Strand:
    - Pre Primary - what is weather?
    - Year 1- patterns of events in weather
    - Year 2- issues that may arise in the future if humans continue to use Earth’s resources faster than they are replenished. They explore how we can be kinder to the environment.
    - Year 4-Earth’s surface changes over time. Considering how Aboriginal and Torres Strait Islander Peoples’ fire management practices over tens of thousands of years have changed the distribution of flora and fauna in most regions of Australia.
    - Year 6- extreme weather events can affect Earth’s surface. Students identify natural disasters caused by extreme weather events.

Attachment 2: Draft outline of proposed Einstein-First Climate Science lessons

Module 1: The Science of Climate

Lesson 1: From Atoms to Climate

A play about the story of the story of climate science that starts with an 1801 expedition to Australia and finishes with the Nobel Prize being awarded for Climate Science in 2021.

Lesson 2: What is the World Made of?

Use pre-test results or a class discussion of prior knowledge to remind students that everything is made of atoms and molecules. Students then will work in groups to create a concept map of the key Einsteinian terms: electrons, nucleus, protons, neutrons, electron cloud, atoms, molecules, photons, phonons and heat vibrations.

Lesson 3: Binding energy

Everything is made of atoms and molecules which are held together by electric forces. It takes work and energy to pull things apart. This is called binding energy. It is a unifying concept across physics, chemistry and biology. When they come back together the energy is released.

Lesson 4: Molecules that make air

Students learn that air is a mixture of different molecules in their gaseous state, and some are in very small concentrations.

Lesson 5: Photons and binding energy: breakers and helpers

Students learn that photons transfer energy to break the binding energy of electrons in metals. But they can also help things join together: from solar panels to photosynthesis:

Lesson 6: Electrons are better than pit ponies – What's a Watt?

Students learn how to talk about and measure the amount of energy and power. Solar panels make streams of electrons. These can power electric motors for lifting things.

Lesson 7: Photons make things grow

Students plant and grow 'one week salad greens' with mini greenhouses in full, half and no light.

Lesson 8: Photosynthesis: Making plants and clean air

Students learn about the making and breaking of bonds in molecules of CO_2, H_2O and CH_4: forces that hold them together, and the way they vibrate.

Huge molecules made of long chains of atoms are essential for life. Here we introduce the idea of long chain molecules without going into detail. Learning the names and the idea that it all starts from photons + CO_2 +water makes glucose and oxygen.

Lesson 9: Combustion: all about candles

Carbon and oxygen have lots of binding energy so lots of energy is released when O_2 combines with Carbon: convection and photons. Fossil fuels from coal, oil and gas come from fossilized plant and animals. Simplest is CH_4

Lesson 10: Respiration

All living things respire. The chemical 'burning of food (glucose molecules) supplies the energy all living things need to live, including to move and grow. Respiration gives of CO_2 and H_2O.

Module 2: Global Warming and Climate Change

Lesson 1: Planet Earth in Empty Space

Students learn how the Sun is the source of most of our energy and this energy is stored and re-emitted into space. They learn about the energy balance and why the average temperature of the Earth's atmosphere is about 15^0C.

Lesson 2: Earth's blanket

Students learn that although there is only tiny amounts of the greenhouse gases CO_2, CH_4, H_2O and N_2O in air, they act as a 'blanket' which traps heat in the Earth's atmosphere and are the cause of global warming.

Lesson 3: Heat on big scales

Students learn that as atoms and molecules absorb more energy they vibrate faster, causing them to need more space. In gases, like the air, and liquids, like the oceans, the molecules become less dense and convection currents are caused in the air and oceans by gravity. The rotation of the Earth also affects these currents. A similar thing happens inside the molten magma inside the Earth's crust. Large temperature differences and the rotation of the earth cause convection currents inside the Earth which 'drive' continental drift.

Lesson 4: Air and Ocean heat transfer

Heat transfer in fluids (the air and the oceans). Climate is driven by temperature differences, the more the difference, the stronger the climate event.

Lesson 5: Getting hotter: the evidence

Students examine key global warming data and Australia temperature data, together with records of the frequency and severity of weather events.

Lesson 6: The weirdness of water

Students see how water expands as it freezes (anomalous expansion of water), explaining why ice floats and ice forms on the surface of water first. This is caused by the shape of and forces between water molecules.

Lesson 7: Underwater archaeology and human migration

Students learn about rock art that has been found up to depths of 100 m, providing evidence of a land bridge between Australia and New Guinea

Lesson 8: Extreme weather

Students investigate the impact of climate change and extreme weather events in Australia using Bureau of Meteorology and Australian Climate Change Authority data. They are then encouraged to participate in one or two extended Climate Action activities

Resources for students to investigate and explore key issues

The following topics could be explored as part of the Humanities and Social Sciences, English, Science as a Human Endeavour Science Strand, and Technologies curriculum:

- Reforestation
- Bushfires and their impact
- Building white cities
- Carbon neutral farming
- Keeping cool.

Module 3: Sustainable energy futures

Lesson 1: Electricity from the Sun

Students will construct a simple circuit using a solar panel as the energy source and then build and test a model solar car. They learn that 'completing the circuit' gives a complete path for the electrons in metals to journey there and back again.

Lesson 2: Magnificent metals

Students construct a model of copper metal from small balls of plasticine gently squeezed into sheets, explore a range of digital images of metals and explore YouTube videos that explain that metal atoms are arranged in sheets within a 'sea' of 'delocalized' electrons that are free to drift around between the sheets of atoms. They then use this model to explain metallic properties such as electrical conductivity.

Lesson 3: Conductors, insulators and semiconductors

Students will test different materials and classify them as conductors and insulators. They will also be introduced to semiconductors.

Lesson 4: Electric circuits

Students will connect a number of different electric circuits to generate electricity and use the motor, globe, three LEDs and buzzer to show electricity is being generated and then converted to other energy forms.

Lesson 5: Exploring power

Students investigate how energy can be generated to lift different weights as the amount of light falling on the solar panel varies according to the angle of its surface in relation to the Sun.

Lesson 6: Batteries and storing electricity

Students construct a simple cell and use it to power a LED or buzzer and measure the voltage and current. They will also observe what has happens when cells are connected. They will learn how batteries allow us to release stored chemical energy from the electrical forces of the bonds in the battery, in our case a lemon. Finally, they will learn how some batteries are rechargeable.

Lesson 7: Electricity from wind and water

Students investigate wind and hydroelectricity turbines, including pumped solar. They are allocated different activities and use this as an opportunity to prepare and present a report for literacy assessment.

Lesson 8: Moving to zero CO_2 emissions transport

Students will observe hydrogen and oxygen being separated from water using electricity produced from PV cells (green hydrogen) and observe the two gases recombining in a fuel cell to produce electricity. This will be supported by a video animation of the fuel cell process. Car dealers selling electric vehicles may be invited to schools to show students how electric vehicles work and how cars, trucks, buses and trains of the future are likely to be driven by fuel cells.

Resources for students to investigate and explore key issues

The following topics could be explored as part of the Humanities and Social Sciences, English, Science as a Human Endeavour Science Strand, and Technologies curriculum:

- Off grid living
- Transport of the future