IMPRESS SYMPOSIUM 2023

Einsteinian Energy for middle school

Shachar Boublil

THE UNIVERSITY OF WESTERN AUSTRALIA

Einstein-First

OzGrav

ARC Centre of Excellence for Gravitational Wave Discovery

International Journal of Science and Mathematics Education
https://doi.org/10.1007/s10763-022-10348-5

Check for updates

Design and Implementation of an Einsteinian Energy Learning Module

Shachar Boublil[1] · David Blair[1] · David F. Treagust[2]

Received: 2 November 2022 / Accepted: 5 December 2022

Abstract

The most famous equation in physics, $E=mc^2$, is rarely introduced in middle school physics curricula. Recent research has shown that teaching Einsteinian concepts at the middle school level is feasible and beneficial. This paper analyses an Einsteinian energy teaching module for Year 8 students (13–14 years old), which encompasses the two fundamental energy formulas in modern physics, $E=mc^2$ and $E=hf$. In the context of activity-based learning, the Einsteinian energy module relates to all the forms of energy in traditional school curricula. This study uses a design-based research approach within the Model of Educational Reconstruction frame-

PAPER

Phys. Educ. **58** (2023) 015003 (11pp) iopscience.org/ped

Model experiments and analogies for teaching Einsteinian energy

Shachar Boublil* and David Blair

Department of Physics, The University of Western Australia, Perth, WA, 6009, Australia

E-mail: 22805164@student.uwa.edu.au

CrossMark

Abstract

The connections between light, matter, and energy are central to Einsteinian physics education in the age of renewable energy and modern technologies. Using activities, models, and analogies for presenting modern physics in the classroom is effective in helping students understand challenging topics. This paper describes three classroom activities designed to explore the physics behind a beautiful experiment that measured an atom's mass increase when it absorbs a single photon and its mass reduction when a photon is emitted. The experiment demonstrates the direct link between $E = mc^2$ and $E = hf$.

[1] Boublil, S., Blair, D. & Treagust, D.F. Design and Implementation of an Einsteinian Energy Learning Module. *Int J of Sci and Math Educ* (2023). https://doi.org/10.1007/s10763-022-10348-5
[2] Boublil, S., & Blair, D. (2023). Model experiments and analogies for teaching Einsteinian energy. *Physics Education*, *53*. https://doi.org/10.1088/1361-6552/ac96c0

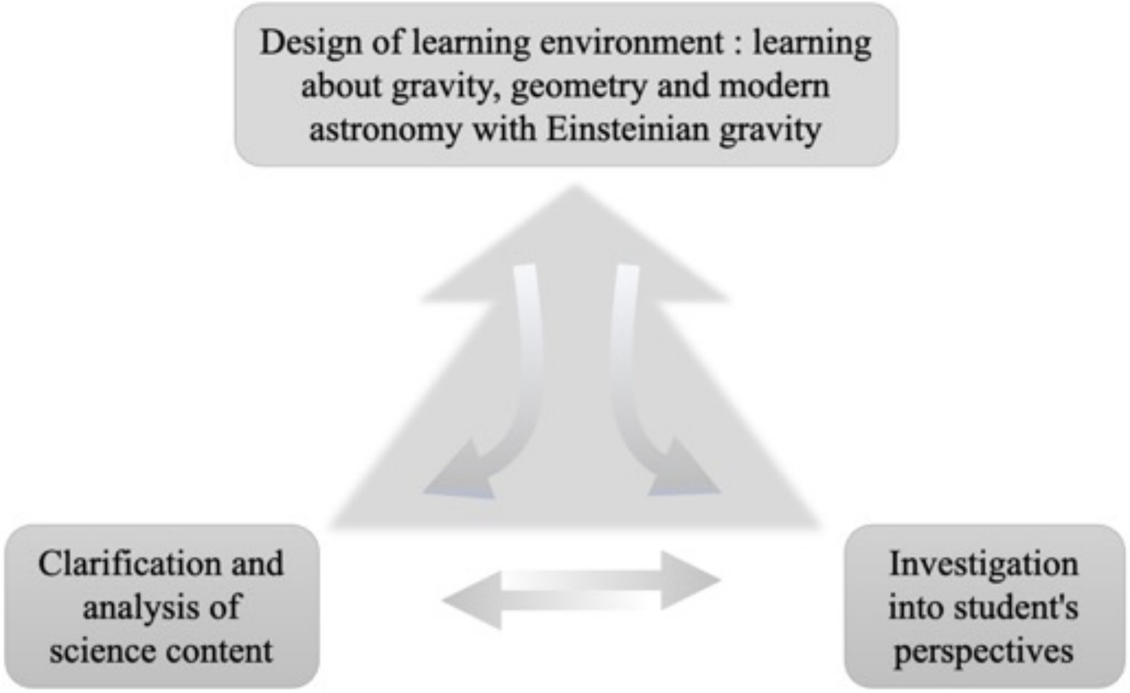
The model of educational reconstruction for the development of an 8 lesson Einsteinian Energy module

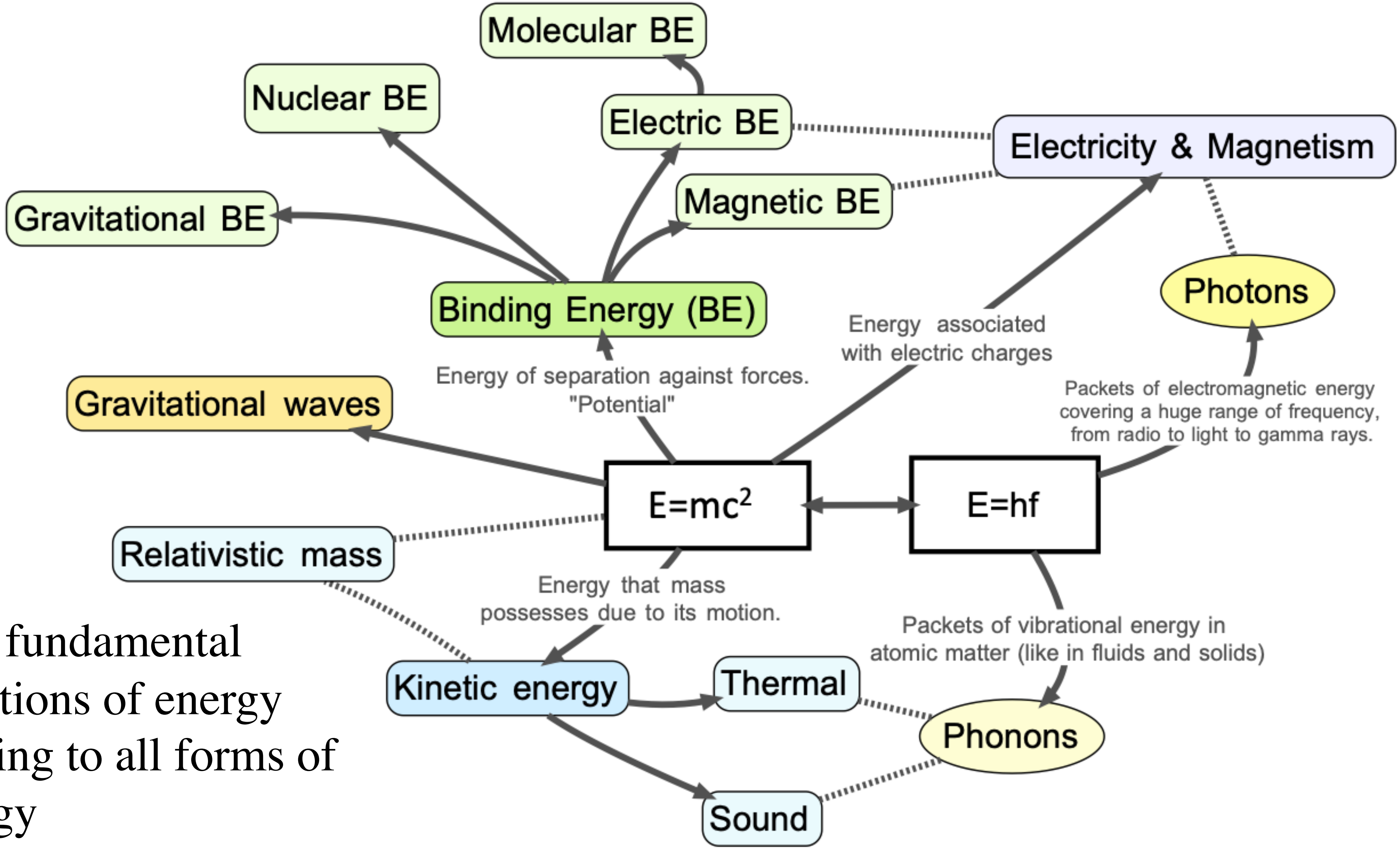
MER contains three components of educational research to guide the development of learning resources:

Selecting key Einsteinian-Energy concepts for a progression of learning

Designing teaching-learning sequences that demonstrate the relevance and applicability of these concepts

Investigation into Students' conceptions and teachers' views on teaching this subject matter.





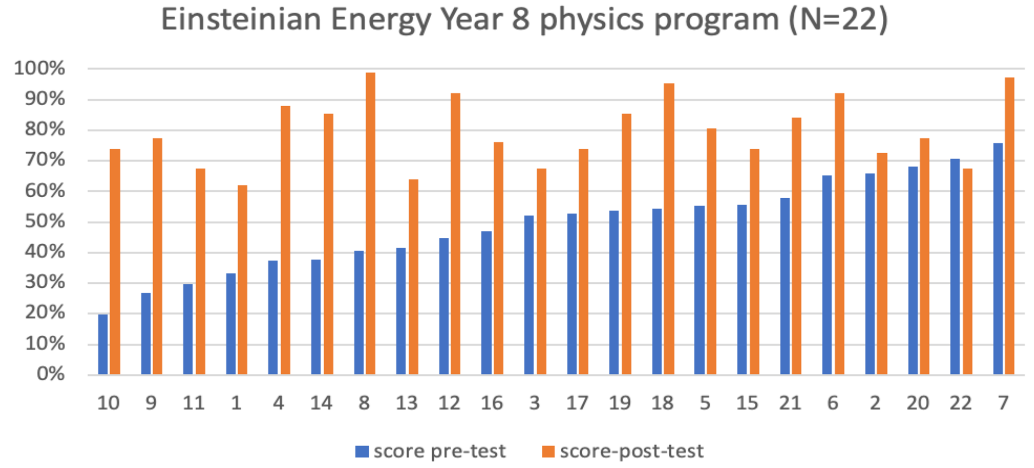
Two fundamental equations of energy relating to all forms of energy

Design principles

1. **Link key mathematical concepts of EE**:
   E=hf – electromagnetic spectrum, photon emission.
   $E=mc^2$ - Gravitational waves, mass loss of the sun, an atom, chemical reactions.
2. **Link key concepts of EE to real-world scenarios using analogies and activities:** *Lasers* - interference, absorption, and emission, *Phasor wheels* - frequency, wavelength and speed, *Magnets* - binding energy, trapping and electricity. *Flexible rulers* – inertia, mass, oscillations.
3. **Focus on the mathematical complexity of equations:** Powers of ten & fermi approximations - energy, frequency, Planck's constant, the speed of light, mass, distance, time, and quantity.
4. **Focus on the history and the nature of scientific** knowledge: Drama-role plays, videos & presentations of scientific events.

Results and conclusion

- The results showed a 31% mean increase in student understanding based on the pre/post-test.
- The results support the notion that middle school students can acquire a qualitative and quantitative understanding of photons and the energy mass equivalence.



Let's stay connected : shachar.boublil@research.uwa.edu.au

Thank you!