Appendix A: Implementation of the Maths for Einstein's Universe program, 2021–2024.

This table summarises the trials of the program across different schools and year levels, including dates, duration, and the specific modules trialled with each group.

Table A. Implementation of *Maths for Einstein's Universe* in 2021-2024:

Program	Modules	Dates	Duration & Sessions	Participants / Year Level
a)	1 and 5	May 2021, Nov. 2022	4 weeks (3 x 1 hr, 1 x 1 hr)	28 / 5-9
b)	3	Jul. 2021	2 days (2 x 2 hr)	27 / 4
c)	1 and 3	Jul. 2021	2 days (3 x 2 hr)	9 / 5-6
d)	1	Sept. 2021	4 weeks (4 x 1.5 hr)	27 / 5-6
e)	1-5	Feb. 2022 - Oct. 2024	100 weeks (100 x 2 hr)	35 / 2-9
f)	1, 2, 3, 5	Jul. 2022, Sept. 2022	3 days (2 x 2 hr, 1 x 2 hr)	26 / 5-9
g)	1	Aug. 2022	4 weeks (4 x 1.5 hr)	30 / 5-6
h)	3	May 2023	4 weeks (16 x 1 hr)	100 / 5-6
i)	1	June 2024 - Aug. 2024	6 weeks (24 x 1 hr)	112 / 5-6
Totals	**1-5**	**2021-2024**	**269 hr**	**389**
Notes: a) After-school voluntary workshops were advertised through the website (https://www.einsteinianphysics.com/) and held at the Einstein-First facility; b), g), h), i) mainstream government schools; c), d) high-achieving groups in government schools; e) long-term program for a stable multi-age class, taught in three different age groups; and f) remote Aboriginal school. The modules column indicates which of Modules 1-5 were trialled with a particular group.				

Appendix B: Overview of professional development courses delivered to teachers.

The table presents venues, duration, and audience for teacher workshops and micro-credential courses delivered as part of the project.

Table B. *Maths for Einstein's Universe* teacher -education courses.

Program	Name of course/workshop	Dates	Duration	Audience
A.	Maths of arrows	Oct. 2021	1 hr	20/Pre-service teachers
B.	Maths for Einstein's Universe (micro-credential courses)	Jan. 2022-Feb. 2022	18 hr	9/Primary and secondary teachers
C.	Maths for Einstein's Universe (micro-credential courses)	Aug. 2022-Oct. 2022	18 hr	8/Primary and secondary teachers
D.	How small is an atom? /Numbers in the Universe on a Chessboard	Oct. 2022	1.5 hr	12/Primary teachers
E.	Maths for Einstein's Universe (micro-credential courses)	May. 2023-Jul. 2023	9 hr	15/Primary and secondary teachers
F.	Maths for Einstein's Universe (micro-credential courses)	Jan. 2024-Oct. 2024	2x10hr	100/Primary and secondary teachers
Totals		**2021-2024**	**66.5 hr**	**163**
Note: a) and d) workshops; b), c), e) and f) part of a 72-hour micro-credential course				

Appendix C: Examples of common student misconceptions prior to instruction.

This table presents misconceptions identified in students' responses before participating in the program, across all five module

Table C. Examples of Student Misconceptions prior to the program.

Module	Misconception	Example
1. Extreme numbers	Students are unaware of the nature of exponential processes.	Asked to guess how many halving you need to reduce a 1-meter tape measure to 1 mm, students often guessed 100 or 1000 when it actually needs only 10.
2.Estimation	Exact numbers always improve understanding.	Students believe that it is important to use all the significant figures in the speed of light to estimate the size of light year.
3.Vectors	No understanding of the concept of performing mathematics with vectors.	Students believe that the resultant obtained by adding several arrows will be different if they are added in a different order
4. Probability	A lack of understanding regarding the concept of independent probability.	Students believe that future coin toss results are dependent on previous ones.
5. Curved Space	All geometric concepts are based on flat space	Students can not envisage the geometric consequences of space being curved such as the fact that parallel lines may cross each other in curved space.

Appendix D Detailed descriptions of four core activities in Module 1 (Extreme Numbers).

Each activity includes its objective, brief description, and the corresponding test question used to assess student understanding.

Table D. Four activities from Module 1 and expected outcomes.

Activity Name	**Description**	**Post-test question**
Ancestor Counts Outcome a) Understanding powers of 2 through doubling and halving.	Doubling using powers of two, students calculate the number of ancestors in any generation. They create an imaginary family tree in the classroom, with classmates playing the roles of parents, grandparents, etc. Starting with themselves, they double to represent their parents, then continue to double for each subsequent generation until they run out of classmates to represent ancestors.	Q1. Here is a family tree. How many great-great-great-grandparents do you have?

Tape Measure Halving Outcome a) understanding powers of 2 through doubling and halving.	Students explore exponential decrease in size by halving of a one-meter tape measure ten times. They count the number of pieces after each cut, imagining each piece being further divided and defining the size of each piece.	Q2. How many times do you have to halve a 1 metre tape measure until you get to approximately 1 millimetre?
Lazy Numbering Outcome b): application of powers of 10 plus multiplication and division.	Arithmetic with powers-of-ten. Students practice quick calculations, finding answers to questions like, 'How many meters is a light year?' or 'How long would it take to travel to the moon at the speed of a car?' They also hold a competition in writing numbers using powers-of-ten versus writing them with zeros.	Q3. What is the answer to ten to the power of three times ten to the power of eleven as shown below? 10^3 x 10^{11}=
Powers of the Universe book Outcome b) application of powers of 10 plus multiplication and division with powers; and Outcome c) expanded logarithmic thinking through activity book *Powers of the Universe.*	Students use an activity book called *Powers of the Universe* in which page numbers are powers of ten, allowing all objects in the visible Universe to be matched to the appropriate scale in meters or kg.	Q4. In your *Powers of the Universe* book, the mass of Jupiter is on page 27 and the mass of Sun is on page 30. Roughly how many Jupiter's do we need to create the Sun? Please give your answer using powers of ten.

Appendix E: Summary of key activities used in Module 3 (Vectors).

The table outlines practical classroom activities used to introduce and develop students' understanding of vectors in classical and quantum contexts**.**

Table E. The main activities for Module 3, *Vectors*

Activity Name	**Description**
Arrow Addition	This activity uses a set of 4-6 magnetic arrows to explore vector addition and the concept of a resultant (Fig. 4a).
Vectors for Forces	These activities explore vector addition to explain forces and introduce the concept of a resultant. Examples include pushing the teacher's car in a carpark, a tug-of-war, and pulling wooden blocks with rubber bands (Fig. 4b).
Vectors for Interference	These activities introduce the quantum nature of light through simple interference experiments (see Fig. 4c) and interpreting bright and dark bands in terms of vector addition represented by a phasor wheel described below.
Phasor Wheel	This simple rolling phasor wheel represents a photon probability wave, allowing students to predict interference patterns on paper and estimate photon arrival probability .

Spinning Tops and Gyroscopes	This set of activities introduces the concept of spin vectors in the context of spinning tops, wheels, and gyroscopes to draw connections to quantum spin.