# Scientific concepts within reach of young learners: Support from educational research literature.

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# Overview of this presentation

- I am a participant in the curriculum development and research project funded by the Australian Research Council led by David Blair at the University of Western Australia.
- This project is designed to modernise physical science teaching in schools by including Einsteinian concepts of space, time, matter and radiation.
- From our recent classroom-based work and that of others we have demonstrated how learning these concepts is possible.
- Now we are implementing in many schools with teachers of Year 3-10 students
- In this short presentation, I provide supporting evidence from the educational research literature that primary and lower secondary students are capable of learning abstract concepts given appropriate supportive learning environments
- Rather than provide a comprehensive literature review, I am basing my comments on the substantial work of Kathleen Metz, UC Berkeley, including the use of ‘within reach’ aspect in the title of this talk.



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# Piaget's stages of logical-mathematical structures and related learning opportunities

- **Positive outcomes**

Research on educational development based on Piaget's ideas has benefitted science teachers and young science learners with many new and improved science curricula and teaching methods.

- **Negative outcomes**

Implied restrictions of some children's learning due to age/stage of development

Observations that children's learning that did not neatly fit these cognitive stages

- **Considerations** (From Metz 1998 p. 81)

Piaget focussed on development not learning

The developmental theory focussed on a child working alone

Need to consider how children think and can understand with effective instruction

Children best learn collaboratively



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# Challenges to Piaget's stage theory from research with primary school children (Metz,1995)

- Using elementary science processes for the first years of schooling and **postponing integrated practice until the higher grades** results in decomposition and decontextualization in the teaching and learning of scientific inquiry. (p. 152)
- In this way, young children engage in science activities such as observation and categorization without a rich goal structure or purpose
- This practice is detrimental from cognitive, motivational, and epistemological perspectives. (p. 152)
- Shortcomings in performance are attributed to the child's stage ---- these shortcomings will disappear with cognitive development. (p. 160)
- Research frequently confounds weak knowledge with developmentally based cognitive deficiencies (p. 160)



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# Domain-specific knowledge and collaborative cognition (Metz, 1995, p. 93)

- Domain-specific knowledge has an impact on the adequacy of children's scientific inquiry
- We cannot assume children are incapable of some form of inquiry without having an understanding of the domain.
- Scaffolding children's deep exploration in a few domains supports inquiry
- Collaboration between children can raise the level of the cognitive task
- Make effective use of the social context to build up children's emergent domain-specific knowledge and scientific inquiry processes.



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# Design principles for teaching young children scientific ideas (Metz 2019 p. 588)

- The recommendation is to frame instruction that systematically engages students' intuitions and emergent ideas.
- Develop children's conceptual understanding and explanatory power in the context of scientific knowledge-building practices.
- Design instruction to problematize key ideas within the children's participation in scientific practices.
- Maximize the power of children's reasoning within these practices by concentrating their inquiry within a single domain
- There is considerable plasticity in young children's capacity to understand abstract scientific ideas, given sufficiently powerful instructional conditions. (Metz, 2019, p. 611)



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# How EinsteinFirst is acknowledging and addressing these issues

- Activities are designed to use children's natural curiosity
- Children are engaged in scientific practices, frequently in group class activities
- Curriculum materials focus on a single domain – for example, introducing particle concepts in Year 3 and developing these ideas over 8 lessons.
- Through songs and games children become familiar with the concepts of simple molecules.
- Teaching support materials and teacher professional development are an integral part of the learning environment



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