Engagement and Impact 2018

Deakin University

DKN13 (SS) - Impact

Overview

Title

(Title of the impact study)

Improving science teaching and learning through representation inquiry

Unit of Assessment

13 - Education

Additional FoR codes

(Identify up to two additional two-digit FoRs that relate to the overall content of the impact study.)

Socio-Economic Objective (SEO) Codes

(Choose from the list of two-digit SEO codes that are relevant to the impact study.)

93 - Education and Training

Australian and New Zealand Standard Industrial Classification (ANZSIC) Codes

(Choose from the list of two-digit ANZSIC codes that are relevant to the impact study.)

80 - Preschool and School Education
81 - Tertiary Education

Keywords

(List up to 10 keywords related to the impact described in Part A.)

Multimodal representation

Representation and learning

Science curriculum

Science inquiry processes

Science teaching approaches

Student learning in science

Student reasoning in science

Teacher professional learning

Sensitivities

Commercially sensitive

No

Culturally sensitive

No

Sensitivities description

(Please describe any sensitivities in relation to the impact study that need to be considered, including any particular instructions for ARC staff or assessors, or for the impact study to be made publicly available after EI 2018.)

Aboriginal and Torres Strait Islander research flag

(Is this impact study associated with Aboriginal and Torres Strait Islander content?
NOTE - institutions may identify impact studies where the impact, associated research and/or approach to impact relates to Aboriginal and Torres Strait Islander peoples, nations, communities, language, place, culture and knowledges and/or is undertaken with Aboriginal and Torres Strait Islander peoples, nations, and/or communities.)

No

Science and Research Priorities

(Does this impact study fall within one or more of the Science and Research Priorities?)

No

Impact

Summary of the impact

(Briefly describe the specific impact in simple, clear English. This will enable the general community to understand the impact of the research.)

Research undertaken by Deakin University's Science, Technology, Engineering and Maths Education (STEME) Group into student-generated representations (including diagrams, 3D models and mathematical symbols) made a significant contribution to reforming science education both in Australia (particularly in Victoria) and internationally. The Representation Construction Approach (RCA) involves students taking an active role in making, negotiating, refining and justifying their own representations in a guided inquiry process. Aligned with the knowledge-building practices of scientists, the RCA impacted policy and practice and positively changed the way teachers and students think about and engage with science.

Beneficiaries

(List up to 10 beneficiaries related to the impact study)

Australian Academy of Science

Australian Government

Communities, schools and students studying STEM subjects

Pre-service and in-service teachers

The Organisation for Economic Co-operation and Development (OECD) and its members

Victorian Government

Countries in which the impact occurred

(Search the list of countries and add as many as relate to the location of the impact)

Australia

Details of the impact

(Provide a narrative that clearly outlines the research impact. The narrative should explain the relationship between the associated research and the impact. It should also identify the contribution the research has made beyond academia, including:
- who or what has benefitted from the results of the research (this should identify relevant research end-users, or beneficiaries from industry, the community, government, wider public etc.)
- the nature or type of impact and how the research made a social, economic, cultural, and/or environmental impact
- the extent of the impact (with specific references to appropriate evidence, such as cost-benefit-analysis, quantity of those affected, reported benefits etc.)

- the dates and time period in which the impact occurred.

NOTE - the narrative must describe only impact that has occurred within the reference period, and must not make aspirational claims.)

STEM participation is linked with national prosperity and sustainability. The lack of engagement with quality learning in science, and low participation in STEM pathways was associated with a dominant transmissive pedagogy focused on low-level comprehension and recall. Redressing this issue, Deakin's STEME Group (led by Professor Russell Tytler, Associate Professor Peter Hubber and Professor Vaughan Prain) conducted a sustained research program to understand and promote quality student learning and reasoning in science.

The Representation Construction Approach (RCA) impacted science education policy, practice and learning in four ways:
1. Student engagement in science
The Deakin research demonstrated that in constructing, coordinating and evaluating multimodal representations, students are more conceptually engaged, with higher-level class discussion and greater understandings generated, e.g. (Tytler et al 2013). Comparative pre- and post-test result showed a substantially enhanced learning dividend for RCA, and research interviews reveal changed teacher perceptions of the nature of teaching and learning, e.g. (Hubber et al 2010). Over the impact period the approach was refined and extended to involve hundreds of teachers and students through: ARC projects including Developing digital pedagogies in inquiry science through a cloud (2013-2016) and Inspiring Science & Mathematics Education (2015-2016); in Victorian DET professional learning programs such as The Primary Science Specialists (2011-2016) and STEM Catalysts (2016-2018); and professional learning work with individual schools, e.g. (Salesian College, 2013-2015).

2. State, national and international science curriculum
The influence of the research on curriculum and policy occurred through highly cited and downloaded manuscripts, invited keynotes, and is evident in the shaping of Victorian and national curricula. The policy take up of the RCA in science curriculum occurred prior to the reference period. However, its ongoing impact is evident in the language of `representation' and `visual representation' written into both curricula, e.g. (F-10 Australian Curriculum (version 8.0) endorsed 18/10/2015). Internationally, the influence of the RCA is evidenced in the OECD student assessment in science. From 2011-2016, Tytler was a member of the Science Expert Group (SEG), responsible for drafting the science framework for the 2015 OECD Programme for International Student Assessment (PISA). In response to input from Tytler and Deakin's STEME Group research, the PISA scientific literacy framework (OECD 2017) was revised to place greater emphasis on the role of representation and modelling in quality science learning and literacy. Key points in the framework include `Identify, use and generate explanatory models and representations' and 'Transform data from one representation to another'. PISA was a major stimulus for the promotion of scientific literacy in science education and given the policy importance of PISA tests in the OECD, the influence of the RCA on national science curricula in participating countries is substantial.

3. Science Curriculum Resources
The representation-focused approach is evident in the design of the major national primary science curriculum resource, Primary Connections (PC), published by the Australian Academy of Science (AAS). Prain was initially the leading literacy consultant on the project. Tytler collaborated in the early framing of the professional learning and unit design. Their research influenced the argument for, and framing of, this AAS initiative, which developed curriculum resources and professional learning approaches now taken up by over 80% of Australian primary schools. Adjunct Prof Keith Skamp (Southern Cross University), a leading science educator and consultant for Primary Connections between 2011-2016, attests to its ongoing impact. Skamp describes a trial unit `Earth's place in space', with its major focus on students learning by generating and testing representations (including their own) as an example of "the impact of Tytler and his colleagues' RCA to learning and its impact on PC curriculum writers".

4. Professional learning for teachers
The STEME Group led the science aspect of a major Victorian DET policy initiative - the Primary Maths and Science Specialist (PMSS) Program (2011-2016), designed to tackle students' falling interest in science by building teacher capacity. The Group devised and delivered the Professional Learning program during 2011-2013, which presented representational work as a key element of reforming teaching and learning. Results showed that by creating the role of science specialist in primary schools, and investing in science as a specialised knowledge area, science can be promoted, science teaching resources better managed, and teachers lacking confidence in science, mentored (Campbell & Chittleborough 2014). The Program received strong teacher endorsement and was subsequently repeated through further iterations, resulting in change to the pedagogical practice of 130 science specialists, representing 60-70 schools.

Apparent in its underlying theoretical structure (where the centrality of student representation construction and critique is emphasized), the RCA is integral to the market-leading science textbook for Australian pre-service teachers, Teaching Primary Science Constructively (TPSC) published by Cengage. Because of the text's significant reach, the RCA influenced the science thinking and practice of thousands of future teachers. Specifically across the 4th ed (2012) and 5th ed (2015), RCA research is extensively cited e.g. (Tytler et al, 2007), and the approach is explicit in content chapters, activities and case studies of students generating, testing and refining their representations of causal explanations. During the reference period, TPSC sold over 18,000 copies and had an estimated 60% market share.

Associated research

(Briefly describe the research that led to the impact presented for the UoA. The research must meet the definition of research in Section 1.9 of the EI 2018 Submission Guidelines. The description should include details of:
- what was researched
- when the research occurred
- who conducted the research and what is the association with the institution)

The RCA research is a response to international concerns about student engagement with science learning. Theoretically, it aligns with contemporary insights into the representational basis of processes of scientific discovery, and classroom learning, and signals a significant departure from, and challenge to traditional cognitive perspectives on learning and teaching. The RCA pedagogy was developed through design-based research, e.g. PMSS Program (2011-16), Switched on Secondary Science Professional Learning (SOSSPL) Program (2011-2012) and extended in partnership with many teachers. It grew out of Hubber and Tytler's research into conceptual change (1996-2005); Tytler's longitudinal research into student reasoning and learning (1998-2005); and Prain's 'writing to learn' research (1992-2002). The challenge of teacher learning was an important aspect of the research. Professional learning community approaches drew on Tytler's teacher and school change research from early in the reference period, and a series of large STEM projects funded by the Victorian DET for which Tytler was principal researcher, e.g. Science in Schools (2003) involving over 400 schools, and the Victorian Principles of Learning and Teaching (PoLT 2004) which were a key component of the Victorian Government's blueprint for schools over the following decade. These research programs put the Deakin Group at the forefront of Australian science education reform.

FoR of associated research

(Up to three two-digit FoRs that best describe the associated research)

02 - Physical Sciences
03 - Chemical Sciences

References (up to 10 references, 350 characters per reference)

(This section should include a list of up to 10 of the most relevant research outputs associated with the impact)

Ainsworth, S., Prain, V., & Tytler, R. (2011). Drawing to learn in science. Science, 333 (26 August), 1096-1097

Campbell, C., & Chittleborough, G. (2014), The New Science Specialist: promoting and improving the teaching of science in primary schools. Teaching Science, the Journal of the Australian Science Teachers Association. Vol 1 pp19-29

Hubber, P, Tytler, R., & Haslam, F. (2010). Teaching and learning about force with a representational focus: Pedagogy and teacher change. Research in Science Education, 40(1), 5-28

Prain, V., & Tytler, R. (2012). Learning through constructing representations in science: A framework of representational construction affordances. International Journal of Science Education, 34(17), 2751-2773

Tytler, R. & Prain, V. (2010). A framework for re-thinking learning in science from recent cognitive science perspectives. International Journal of Science Education, 32(15), 2055-2078

Tytler, R., & Prain, V. (2013). Representation construction to support conceptual change. In S. Vosniadou (ed.) Handbook of research on conceptual change (pp. 560-579). New York: Routledge

Tytler, R., Peterson, S. & Prain, V. (2006). Picturing evaporation: Learning science literacy through a particle representation. Teaching Science, the Journal of the Australian Science Teachers Association, 52(1), 12-17. (Awarded 'Most valuable paper' for 2006)

Tytler, R., Prain, V. & Peterson, S. 2007. Representational issues in students’ learning about evaporation. Research in Science Education, 35 (1), pp. 63-98 and 37(3), pp. 313-31

Tytler, R., Prain, V., Hubber, P., & Waldrip, B. (Eds.). (2013). Constructing representations to learn in science. Rotterdam, The Netherlands: Sense Publishers

OECD (2017), PISA 2015 Assessment and Analytical Framework: Science, Reading, Mathematic, Financial Literacy and Collaborative Problem Solving, PISA, OECD Publishing, Paris, https://doi.org/10.1787/9789264281820-en

Additional impact indicator information

Additional impact indicator information

(Provide information about any indicators not captured above that are relevant to the impact study, for example return on investment, jobs created, improvements in quality of life years (QALYs). Additional indicators should be quantitative in nature and include:
- name of indicator (100 characters)
- data for indicator (200 characters)
- brief description of indicator and how it is calculated (300 characters).)