Australian Government
Australian Research Council

Engagement and Impact 2018

The University of Queensland

QLD13 (SS) - Impact

Overview

Title

(Title of the impact study)

Improving mathematics teaching to integrate numeracy learning across the curriculum

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

Keywords

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

Numeracy

Mathematical inquiry

Mathematics pedagogy

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.)

Two related strands of mathematics education research have addressed persistent needs in schools to make mathematics more relevant for students by focusing teaching and learning on the utility of mathematics in applications. Research-led efforts to integrate numeracy across the curriculum have challenged traditional paradigms about mathematics teaching and learning. UQ's practical, collaborative approach has informed change in the pedagogy underpinning the Australian Curriculum, turning the teaching of mathematics towards solving problems in other scenarios. This UQ-led research has had an impact on mathematics curriculum and pedagogy locally, nationally and internationally.

Beneficiaries

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

Australian teachers and students via the Australian Curriculum

Queensland Department of Education

NSW Department of Education

South Australian Department of Education

Queensland College of Teachers

OECD through Programme for the International Assessment of Adult Competencies (PIAAC)

Brisbane Catholic Education

Australian Department of Education

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.)

Mathematics education researchers in UQ's School of Education have influenced a significant paradigm shift in how numeracy is implemented, evaluated and refined across the curriculum in Australian schools. Through two related strands of research (numeracy and mathematical inquiry), they have collaboratively generated, studied and supported opportunities for students to engage in mathematics relevant to citizens, professionals and expert mathematicians.

UQ's integrated theoretical and practical approach designed strategies that transferred directly to the classroom. The numeracy research strand influenced classroom practice via the translation of Numeracy as a General Capability of the Australian Curriculum (localised in QLD, NSW and SA), and then internationally through a review of the OECD's Program for the International Assessment for Adult Competencies (PIAAC) numeracy assessment framework and OECD's Strategic Advisory Group, which has proposed a broadened perspective on numeracy for the next Programme for International Student Assessment (PISA). The mathematical inquiry research strand directly impacted Curriculum to Classroom (C2C)—the QLD implementation of the Australian Curriculum: Mathematics, extended in 2015 to the NT and the ACT.

The numeracy research led by Prof. Merrilyn Goos provided schools and state agencies with a tool (Numeracy Model) to design and audit numeracy learning across the curriculum. The Numeracy Model was validated in primary and secondary schools in three states, and adopted as a curriculum and task design framework by the QLD and NSW governments and the Queensland College of Teachers (QCT).

The Numeracy Model's practical application attracted projects in 2010-2012 with Brisbane Catholic Education to design numeracy leadership programs, and with the Australian Department of Education to evaluate the Australian Association of Mathematics Teachers' numeracy for Indigenous learners project, 'Make It Count'. A project with the QCT (2014-15) designed numeracy resources for teachers, including a forum to inform university teacher education. In 2016, the NSW Department of Education incorporated the Numeracy Model into its P-10 Numeracy Skills Framework. Goos and her colleagues secured a contract to write a teacher education book on embedding numeracy across the curriculum. The Numeracy Model also informed a 2016 OECD Review of the PIAAC numeracy assessment framework and the OECD's Strategic Advisory Group, which has proposed a broadened perspective on numeracy for the next PISA.

"The engagement and benefits of the research… have influenced the beliefs and actions of Brisbane Catholic Education and the decisions made in regard to numeracy learning and teaching… will continue to be a resource of knowledge used by the system to inform future decisions." - Pam Betts, Executive Director, Catholic Education.

"The potential impact and benefits of this research will be seen in coming years as graduates exit their initial teacher education programs with improved knowledge and practice in the area of numeracy." – John Ryan, Director, QCT.

Communicating and building on the numeracy strand of research, its models and impacts also occurred at educator conferences, e.g. the QLD Department of Education referred to the Numeracy Model as a "shared numeracy philosophy" for systems at the 2015 Queensland Numeracy Summit, attended by 230 teachers, teacher educators, pre-service teachers, school principals and leaders, education system representatives, and professional association executives.

Mathematical inquiry, the second research strand, included a model developed by Sue Allmond and Jill Wells (two participating teachers) and A/Prof Katie Makar. This model, and the expertise of the research team and 54 participating teachers, influenced 44 multi-lesson inquiry units in the QLD Department of Education's C2C implementation of the Australian Curriculum: Mathematics. C2C was used by 1000+ Queensland's State Schools with nearly half of a million students from Prep to Year 9, later extended to Catholic Education, Independent Schools and all schools in the NT and the ACT. These units emerged from two ARC Linkage Projects with the

Department.

"The high-quality data collected from this project will act as long term advice for the Department in developing future directions in mathematics." – Rhonda Horne, Manager Strategic Improvement, QLD Department of Education.

In 2011, teachers in the Linkage Projects helped the C2C writers design the units and Makar provided expert feedback as they elaborated on the inquiry units over 2012-14. A joint symposium with the research team and the Department was presented in 2013 in Melbourne. These units and the inquiry model were later offered to Catholic Education and Independent Schools in QLD and all NT schools. This outcome attracted two consultancy projects in 2013 and 2016: with US company Amplify, to design a tablet-based curriculum for Years 6-8; and with the Australian Academy of Science to design 10 units of inquiry for Years F-6. Cognition Education (NZ) engaged Makar in 2015 to deliver mathematical inquiry professional development training for teachers across the country and provide online media for the teacher website NZMaths.

Four new lines of inquiry also opened out of this research: 1) how secondary teachers of subjects other than mathematics develop an identity as an embedder of numeracy into these subjects; 2) how teachers become numeracy and mathematical modelling task designers – conceptualising task design (not just consuming tasks designed by "experts") and enacting these tasks in the classroom; 3) how pre-service teachers can prepare to embed numeracy in the subjects they teach; and 4) how mathematical inquiry promotes students' positive disposition/"growth mindset" towards mathematics.

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 research team comprised six primary academics: Goos (UQ), Makar (UQ), Geiger (ACU), Dole (USC), Fielding-Wells (UQ), and Forgasz (Monash), and seven additional contributors. Between 2002-2016, the study was funded by eight ARC Linkage and Discovery Projects, multiple funded contracts, and associated seed funding totalling nearly $3 million.

The research focused on two key strands: numeracy and mathematical inquiry. The numeracy strand, led by Prof. Goos, challenged narrow "basic skills" interpretations of numeracy that prepare low-achieving students to do no more than "survive" in the world beyond school. In contrast, the Numeracy Model developed in this research recognised the intellectual, affective and contextual demands of becoming a numerate person, as well as the insights numeracy offers into disciplinary understandings across curriculum areas. The mathematical inquiry strand of the research, led by A/Prof. Makar, provided practical, evidence-based approaches to engage students in solving complex everyday problems.

Both strands worked to build students' capacity and valuing of mathematics as a productive tool for citizenship, personal needs and professional life. This research was carried out in classrooms, where traditional research methodologies are challenging to implement. This research context, however, allowed the impact of the work to be both informed by and immediately applicable to classroom contexts.

FoR of associated research

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

13 - Education

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)

Hilton, A., Hilton, G., Dole, S., & Goos, M. (2016). Promoting middle school students' proportional reasoning skills through an ongoing professional development programme for teachers. Educational Studies in Mathematics, 92,

193-219.

Goos, M. (2015). Learning mathematics in a classroom community of inquiry: Examples from a secondary mathematics classroom. In E. A. Silver & P. A. Kenney (Eds.), More lessons learned from research: Useful and usable research related to core mathematical practices (Vol. 1, pp. 293-299). Reston, VA: National Council of Teachers of Mathematics.

Makar, K., Bakker, A., & Ben-Zvi, D. (2015). Scaffolding norms of argumentation-based inquiry in a primary mathematics classroom. ZDM – The International Journal on Mathematics Education (Zentralblatt für Didaktik der Mathematik), 47(7), 1107-1120. 10.1007/s11858-015-0732-1

Goos, M., Geiger, V., & Dole, S. (2014). Transforming professional practice in numeracy teaching. In Y. Li, E. Silver, & S. Li (Eds.), Transforming mathematics instruction: Multiple approaches and practices (pp. 81-102). New York: Springer.

Geiger, V., Goos, M., & Dole, S. (2014). The role of digital technologies in numeracy teaching and learning. International Journal of Science and Mathematics Education, 13(5), 1115-1137.

Fielding-Wells, J., Dole, S., & Makar, K. (2014). Inquiry pedagogy to promote proportional reasoning in primary students. Mathematics Education Research Journal, 26(1), 47-77.

Makar, K. (2012). The pedagogy of mathematical inquiry. In R. Gillies (Ed.), Pedagogy: New developments in the learning sciences (pp. 371-397). Hauppauge NY: Nova Science.

Goos, M., Dole, S., & Geiger, V. (2011). Improving numeracy education in rural schools: A professional development approach. Mathematics Education Research Journal, 23(2), 129-148.

Allmond, S., Wells, J., & Makar, K. (2010). Thinking through mathematics: Engaging students with inquiry-based learning (Books 1-3, 312p). Melbourne: Curriculum Press.

Goos, M. (2004) Learning mathematics in a classroom community of inquiry. Journal for Research in Mathematics Education, 35, 258-291.

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).)