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Research results and news from ACER

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Conference special edition

This edition of eNews features papers and updates from ACER's annual conference. Research Conference 2010, Teaching Mathematics? Make it count, was held at the Crown Conference Centre, Melbourne on 16-17 August.

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English restricts the language of mathematics

The international mathematics education community's capacity to study, understand and enact classroom practice is constrained by the dominance of the English language, Professor David Clarke will told the ACER annual conference in Melbourne on 16 August.

In the opening keynote address Professor Clarke, the Director of the International Centre for Classroom Research at the University of Melbourne, told delegates that the emergence of English as the 'lingua franca' has restricted international access to some of the subtle and sophisticated concepts used by mathematics teachers and teacher educators in non-English speaking countries.

"The theories we construct are constrained to those ideas and relationships we are capable of naming," Professor Clarke said.

"Each community has developed its own language to describe those things it values. This is particularly true in education. The insights of a culture are embedded in those activities it has chosen to name."

Professor Clarke's presentation focused on a study of the use of mathematical language in the classroom in which he analysed video records of five mathematics lessons from each of 21 classrooms in Berlin, Hong Kong, Melbourne, San Diego, Seoul, Shanghai, Singapore and Tokyo and compared the extent to which students or teachers used key mathematical terms as a proportion of all classroom conversation.

In some of the classrooms studied –for example some of the classrooms in Shanghai, Melbourne, San Diego and Singapore – the spoken use of mathematical terms was actively promoted. Some other classrooms, such as those in Seoul, provided very limited opportunities for students to 'talk mathematics.'

"These differences in classroom practice reflect important differences in valued forms of learning and in the means by which different communities think learning is best promoted," Professor Clarke said.

He said that, despite the frequently assumed similarities of practice in Asia, the study revealed profound differences in the nature of students' spoken mathematics in different Asian classrooms.

"What really interests me is that these cultures have a history of success in mathematics and yet their classroom practice can appear at first glance to contest pretty much all of the things that we've taken as a given," Professor Clarke said.

"By examining learning in such contrasting classrooms, we have a much better chance to identify those conditions most conducive to mathematics learning and also to see the role that culture plays in shaping both our educational goals and the practices by which we attempt to achieve them."

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David Clarke is a Professor of Education and the Director of the International Centre for Classroom Research (ICCR) at the University of Melbourne. Over the last 15 years, Professor Clarke's research activity has centred on capturing the complexity of classroom practice through a program of international video-based classroom research.

Professor Clarke's conference paper, entitled Speaking in and about Mathematics Classrooms Internationally: The technical vocabulary of students and teachers and his presentation slides are available from the ACER research repository.

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Mathematics teaching and learning to reach beyond the basics

Mathematics teachers and textbooks should provide more instruction on reasoning to encourage learning that goes beyond the basics, University of Melbourne Foundation Professor of Mathematics Education Kaye Stacey told the ACER conference on 17 August.

In the opening keynote address on day two of the annual research conference, Professor Stacey drew on her research into mathematical reasoning and suggested why and how it should be given a more prominent place in Australian mathematics classrooms.

“Learning about reasoning establishes a feeling that mathematics makes sense and is not just a set of arbitrary rules,” Professor Stacey said.

According to Professor Stacey, Australian mathematics lessons are currently characterised by a ‘shallow teaching syndrome’ of low complexity problems undertaken with excessive repetition, and an absence of mathematical reasoning and connections in classroom discussion.

Professor Stacey believes there is a need for teachers to possess sufficiently strong mathematical knowledge and deep understanding of mathematical teaching theory.

She suggested that teachers receive guidance on what type of reasoning they can expect and encourage at each year level, as well as the provision of additional support for educators teaching outside their field or specialisation.

Furthermore, mathematical reasoning would be given more prominence if the major purpose of explanations in textbooks was to establish thinking tools for use in subsequent problems.

“The difficulty of the learning is heightened by the hierarchical nature of mathematics, where skill is built on skill and concept is built on concept,” Professor Stacey said.

“No wonder that learning ‘the basics’ can easily fill all the time in school devoted to mathematics.”

Kaye Stacey is Foundation Professor of Mathematics Education at the University of Melbourne and the leader of the Science and Mathematics Education cluster. She works as a researcher, primary and secondary teacher educator, supervisor of graduate research and as an adviser to governments.

Professor Stacey's conference paper, Mathematics teaching and learning to reach beyond the basics, and her presentation slides are available here: http://research.acer.edu.au/research_conference/RC2010/17august/1.

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Mathematics curriculum must address 'spectacular' student diversity

A leading American expert in mathematics education told delegates to the ACER annual conference that curriculum standards set for students are written as an 'immaculate progression' but in reality students arrive each day with a spectacular variety of mathematical biographies.

Philip Daro, one of three leading the writing of Common Core State Standards (CCSS) in Mathematics in the United States argued that more consideration must be given to the diversity among students.

Mr Daro was visiting Australia to deliver a keynote address to the ACER annual conference. He said that each state in the U.S. has had its own standards until now. The CCSS have been adopted by over 30 states.

Mr Daro argued that the process of developing curriculum content standards for school mathematics is complicated by the fact that they need simultaneously to take account of:

- research evidence about the nature of mathematics learning, and in particular, the sequence in which students typically develop mathematical understandings;
- policy decisions about the mathematics that all students should be learning as a matter of priority; and
- the 'spectacular diversity' of students' levels of mathematics achievement in any given year of school.

"If curriculum content standards do not take all three of these factors into account, then they can be seriously at odds with what happens in classrooms," Mr Daro said.

"For example, some standards fail to recognise the great diversity in students' levels of mathematics achievement in any given year of school. They are written as though students have learned everything (100%) in the standards for the preceding grades.

"This assumption of an 'immaculate progression,' is a wild fiction in any real classroom."

According to Mr Daro, teachers need tools that illuminate rather than obscure the varying individual learning trajectories that students are on.

Rather than portraying where students 'can' or 'should' be at a given point in time, standards should 'map' stations through which students are led in their mathematics learning, from wherever they start.

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Philip Daro was a member of the lead writing team for the Common Core State Standards in Mathematics. He has directed, advised and consulted to a range of mathematics education projects.

Mr Daro's conference paper, Standards, what's the difference? A view from indisde the development of the Common Cord State Standards in the occasionally United States, and presentation slides are available from the ACER research repository.

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Success in maths adds up to personal power

Students' attitudes to mathematics can determine their success or failure, and ultimately their social status as adults, according to emeritus professor of the philosophy of mathematics education at Exeter University in the United Kingdom Paul Ernest.

Professor Ernest spoke about the social outcomes of learning maths at the Australian Council for Educational Research (ACER) conference in Melbourne on 17 August.

"Many students develop negative attitudes about maths and about their own ability," Professor Ernest said.

"Attitudes are vital to success, and for students a lack of confidence becomes a self-fulfilling prophecy."

Negative attitudes lead to a 'failure cycle'. Students fail at one task and think they don't have maths 'talent'. They lose confidence, stop trying, and continue to fail at maths, which reinforces their perception that they lack talent.

Instead, maths education should bust the myths about maths, which include that:

- success in maths is due to talent rather than to effort
- boys are better at maths, and
- maths is unrelated to day-to-day life.

Professor Ernest said that teachers must bust the myths about maths to ensure students make the effort to learn and this will lead to a 'success cycle'. Students put in effort, succeed at a maths task, gain confidence, and continue to be motivated in maths.

"Attitudes, beliefs and values have a strong influence on how students learn maths. We need to pay much more attention to this in school," Professor Ernest said.

"Teachers should help students to develop mathematical confidence and creativity, a broad appreciation of maths, and even social empowerment through maths.

"Contrary to popular belief, mathematics is a political subject. Economics is applied mathematics and this is the main language of politics, power and personal functioning in society. It is essential for a functioning democracy.

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"Maths is embedded in social, commercial and political systems, from advertising in the financial sector to government and interest-group claims. Understanding maths allows citizens to critically evaluate information, where necessary to reject spurious claims, and to ensure they are not misled.

"People need to understand maths to be successful in day-to-day life," he said.

Professor Ernest's paper entitled The social outcomes of school mathematics: Standard, Unintended or Visionary? and his presentation slides are available from the ACER research repository.

Prior to the conference Professor Ernest published an article based on his forthcoming conference paper in the June 2010 edition of Professional Educator. His article, Add it up: why teach mathematics? Professional Educator, 9 (2), June 2010, pp. 44-47, is also available from the ACER research repository.

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Identifying cognitive processes important to mathematics learning but often overlooked

Six competencies that are fundamental to the development of 'mathematical literacy', or a person's ability to apply their mathematical knowledge to practical situations, were presented at the ACER Research Conference in Melbourne on 16 August.

The competencies are communication, mathematising, representation, reasoning, devising strategies, and using symbolic, formal and technical language and operations.

"These competencies can be thought of as a set of individual characteristics or qualities possessed to a greater or lesser extent by individuals," said Ross Turner, Principal Research Fellow at ACER.

"The more you possess these competencies, the better able you will be to make effective use of your mathematical knowledge to solve contextualised problems."

Using examples from the 2003 OECD Programme for International Student Assessment (PISA) Mr Turner demonstrated that different mathematical problems call for the activation of the six competencies, to a differing extent.

Mr Turner said that currently not enough time and effort is devoted to fostering the development of these fundamental competencies and proposes that the competencies should be directly targeted and advanced in our mathematics classes.

"Current curriculum structures do not provide sufficient incentive for teachers to focus on these competencies as crucial outcomes," Mr Turner said.

"Students need to be given opportunities to articulate their thinking about mathematics tasks and about mathematical concepts."

He argued that developing mathematical literacy at school is important because students will need to apply their mathematical knowledge to handle real world challenges such as those encountered in the workplace, during leisure and in life as a citizen.

"The mathematical capabilities students demonstrate by the time they are nearing school leaving age foreshadow the approach those individuals will take to using mathematics later in life."

He said that the problem is the opportunities to use mathematics that we come across in life are not packaged in the same way they were in school.

"At school you knew when you were going to mathematics class and you knew the mathematics teacher would show you new mathematical ideas or skills, give you some examples and then point you to a set of exercises more or less like those used to demonstrate the idea or skill you were learning."

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"In the real world, that's not normally how opportunities to use mathematics come to us. We have to make the judgments and decisions about what mathematical knowledge might be relevant, and how to apply that knowledge."

Ross Turner manages ACER's International PISA project, coordinating the ACER team and international consortium partners to meet the requirements of ACER's contract with the OECD. He has filled this role as a Principal Research Fellow since 2007, and before that provided general leadership and management to the PISA project and to other ACER projects as a Senior Research Fellow since 2000. Ross also provides leadership in the mathematics area, having led PISA mathematics framework and test development and being responsible for PISA mathematics implementation throughout his time at ACER.

Ross Turner's presentation, Identifying cognitive processes important to mathematics learning but often overlooked, and presentation slides are available from the ACER research repository.

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Counting is not the only way to add up

Counting is not the only way that children can solve arithmetic problems a mathematics conference in Melbourne heard on 17 August.

In a presentation to the ACER annual conference Robert Reeve, Associate Professor of Psychological Sciences at the University of Melbourne, described how Indigenous children from remote areas of the Northern Territory were able to add successfully by reproducing a pattern from memory.

Reeve and his colleagues tested 32 children aged four to seven years: 13 Warlpiri-speaking children and 10 Anindilyakawa-speaking children from two remote areas in the Northern Territory and nine English-speaking children from Melbourne.

“The Warlpiri and Anindilyakwa languages have very limited number vocabularies,” Professor Reeve explained.

“Although these languages contain quantifiers such as few, many, a lot and several these are not relevant number or counting words since they don’t refer to exact numbers.”

All of the children in the study were asked to reproduce two groups of counter tokens placed on a mat by a researcher. Researchers were curious to find out how the Indigenous children would approach the problem when they were not familiar with the concept of counting.

Indigenous children tended to use a pattern strategy to solve the problem by remembering how the two groups of tokens appeared on the mat. When using a pattern strategy the Northern Territory children were more likely to solve the problem correctly. None of the Indigenous children used their fingers to help them with the task.

In contrast most of the children from Melbourne tackled the task by counting the number of tokens they saw on the mat and attempted to select the same amount. They almost never used a pattern strategy.

“The findings suggest that counting words are far from being necessary for exact arithmetic,” Professor Reeve said.

“Rather counting words offer one strategy among others and the pattern strategy appears effective for Indigenous children.”

“Previous research has shown that Indigenous Australians seem to be very good at remembering spatial patterns,” Professor Reeve explained.

“Indigenous Australians rarely transmit information or skills by verbal instruction. Children are encouraged to learn by observation. This may mean that children acquire skills of remembering what they see earlier or better than non-indigenous children.”

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Associate Professor Robert Reeve is currently an associate professor in the Department of Psychological Sciences, in the Faculty of Medicine, Dentistry and Health Sciences at the Universityof Melbourne. He runs the Developmental Math Cognition group in Psychology Sciences, members of which study the nature and origins of children's mathematical learning difficulties.

Robert Reeve's conference paper, Using mental representations of space when words are unavailable: Studies of enumeration and arithmetic in Indigenous Australia and presentation slides are available from the ACER research repository.

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Culture and language must be considered in mathematics learning

Planning for quality learning in maths must take culture, language, attendance and core mathematical understanding into consideration to help Indigenous learners succeed, according to a paper presented at the ACER annual conference.

Griffith University Professor of Education, Robyn Jorgenson, told conference delegates on 16 August that Indigenous students may have gaps in their mathematical understanding, lower attendance rates, culture and languages that are significantly different from that of mainstream schools.

“Teachers need to develop skills that will enable them to learn to plan and adapt to these challenges,” Jorgenson said.

Professor Jorgenson will point to statistics that show attendance rates for Indigenous secondary school students decline as the level of remoteness increases. This may be attributed to the fact that in many remote areas, cultural activities take priority over schooling and result in substantive periods of missed school.

“Never sure if there will be one or two students or 20 students, teachers are required to be professional and prepare as if there will be a full contingent of students attending,” Professor Jorgenson said.

According to Professor Jorgenson, the mathematical understanding of Indigenous students in remote communities is further complicated by the limited need for number and text.

“Many remote Indigenous students do not know their age or birthday; few have phones in the home; streets are not named or numbered; there is no need for large numbers.”

Jorgenson said the teaching force in remote areas is predominantly early career teachers who have had little or no exposure to remote education, to working with Indigenous students and communities and to teaching as a profession, which can contribute to high turnover rates and difficulties in retaining teachers in remote areas.

“Beginning and established teachers need to be able to develop innovative models of planning for diversity in learning needs and demands of remote education,” Professor Jorgenson said.

“Working within the existing dominant concepts will not produce the outcomes required for successful Indigenous education.”

Professor Jorgensen has worked in the area of equity in mathematics education for more than two decades. Her work explores how the social, political and cultural contexts contribute to the exclusion of some students as they come to learn school mathematics. The particular foci of her work have been in the areas of social class, geographical location (rural and remote) and Indigenous contexts and learners.

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She recently took leave from the university sector to work with Anangu communities in Central Australia. The immersion in the lived worlds of remote Aboriginal education has provided key insights into the delivery of Western education in remote Australia.

Professor Jorgensen's conference paper, Issues of social equity in access and success in mathematics learning for indigenous students, and presentation slides are available from the ACER research repository.

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Technology must partner not serve mathematics learning

Digital technology should be a partner to learning mathematics rather than a servant by becoming a substitute for work done with a pencil and paper according to a University of Queensland academic.

In her address to the Australian ACER annual conference, Professor Merrilyn Goos discussed the ways in which research, classroom practice and curriculum policy in the use of digital technologies line up with each other and inform each other.

“For learners, mathematical knowledge is not fixed but fluid, constantly being created as the learners interact with ideas, people and their environment,” Professor Goos said.

“Technology, when part of the learning environment, can change the nature of school mathematics by engaging students in more active mathematical practices such as experimenting, investigating and problem solving, that bring depth to their learning and encourage them to ask questions rather than only looking for answers.”

Professor Goos argued that there is room for improvement in the in the draft K-10 and senior secondary national curriculum for mathematics as technology appears to be treated as an add-on that replicates by-hand methods of learning.

“Although the technology messages contained in the Australian curriculum – Mathematics do not do justice to what research tells us about effective teaching and learning of mathematics, it is almost inevitable that there are gaps between an intended curriculum and the curriculum enacted by teachers and students in the classroom,” Professor Goos said.

“Many teachers are already using technology effectively to enhance students’ understanding and enjoyment of mathematics. In their hands lies the tasks of enacting a truly futures-oriented curriculum that will prepare students for intelligent, adaptive and critical citizenship in a technology-rich world.”

Merrilyn Goos is Director of the Teaching and Educational Development Institute at The University of Queensland. From 1998–2007 Professor Goos co-ordinated pre-service and postgraduate courses in mathematics education at UQ. Her research in mathematics education has investigated secondary school students’ learning, teaching approaches that promote higher order thinking, mathematics teachers’ learning and development, and the professional learning of mathematics teacher educators.

Professor Goos’ conference paper entitled Using Technology to support effective mathematics teaching and learning: what counts? and her presentation slides are available from the ACER research repository.

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Conference proceedings available online

The full proceedings as well as individual papers from Research Conference 2010 are now available from the ACER research repository. Speakers' presentation slides are also available. Visit http://www.acer.edu.au/conference for further information.

Research Conference 2011

ACER's annual conference heads to the Northern Territory for the first time in 2011. Research Conference 2011 will take place in Darwin from 7-9 August 2011 on the theme Indigenous Education: Pathways to success. Further information will be posted to the conference website as it becomes available.

Australian Council for Educational Research
Private Bag 55, Camberwell, Victoria Australia 3124
Tel: + 61 3 9277 5555
Fax: + 61 3 9277 5500
Web: www.acer.edu.au