Culture of **E**vidence-based **M**athematics **E**ducation for **N**ew **T**eachers **(CEMENT)**

Final report of the:

Building the culture of evidence-based practice in teacher preparation for mathematics teaching

2013

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List of acronyms used

AAMT	Australian Association of Mathematics Teachers
AARE	Australian Association for Research in Education
ACARA	Australian Curriculum, Assessment and Reporting Authority
ACDE	Australian Council of Deans of Education
AITSL	Australian Institute of Teaching and School Leadership
ANOVA	Analysis of Variance
BEd	Bachelor of Education
BLF	Beliefs about mathematics and its teaching
CEMENT	Culture of Evidence-based Mathematics Education for New Teachers
DipEd	Diploma of Education
ECE	Early Childhood Education
LBLF	Lecturer beliefs about mathematics and its teaching
LMCK	Lecturer mathematical content knowledge
LPCK	Lecturer pedagogical content knowledge
MAT	Mathematical Association of Tasmania
MCK	Mathematical Content Knowledge
MERGA	Mathematics Education Research Group of Australasia
MKT	Mathematical Knowledge for Teaching
MTeach	Master of Teaching
NESB	Non-English speaking background
NSW	New South Wales
NT	Northern Territory
OLT	Australian Government Office for Learning and Teaching
PCK	Pedagogical Content Knowledge
PM	Project Manager
PST	Pre-service Teacher
QLD	Queensland
SA	South Australia
TAS	Tasmania
TDG	Teaching Development Grant
TEDS-M	Teacher Education and Development Study in Mathematics
VIC	Victoria
WA	Western Australia

Executive summary

***C**ulture of **E**vidence-based **M**athematics **E**ducation for **N**ew **T**eachers* (CEMENT), originally titled *Building the culture of evidence-based practice in teacher preparation for mathematics teaching,* aimed to deliver a process for providing evidence about the quality of pre-service teachers' (PSTs) outcomes in mathematics education in ways that would allow universities to improve their provision of mathematics education. The project took place between 2010 and 2012, at a time when the quality of teachers and initial teacher education was under scrutiny, especially in mathematics education. It was increasingly being recognised that school leavers had neither the disposition nor the mathematics background to undertake courses that required a sound mathematical knowledge, and that changes were needed at all levels of schooling.

It was apparent from the previous research base that teachers needed more than mathematical knowledge alone. The specialised knowledge of mathematics that teachers need was termed Pedagogical Content Knowledge (PCK) following Shulman's (1987) delineation of knowledge types for teaching. Adapting a framework from the TEDS-M international study (Tatto et al, 2008) the CEMENT project developed online instruments to measure beliefs about mathematics and its teaching, mathematics content knowledge (MCK) and mathematics PCK. Using these instruments with pre-service teachers (PSTs) at primary level (and, later, at secondary level), and with mathematics educators, as well as collecting other information about the nature of initial teacher education mathematics education, the project was able to provide sound evidence-based recommendations to participating universities and beyond.

Primary PSTs achieved lower on the PCK scale than the MCK or BLF scales. The same was true of mathematics educators overall, although the patterns of response were somewhat different. In terms of background, higher levels of mathematics on entry did predict MCK but not PCK, which appeared to develop over time. There was no difference between PSTs who studied at distance or on-campus, or who undertook full-time or part-time study. Among mathematics educators, those with continuing appointments achieved higher on the PCK scale whereas casual and short-term contract lecturers achieved better on the MCK scale.

CEMENT has attracted considerable interest among mathematics educators. The outcomes from the CEMENT project have been widely disseminated and have been used in a variety of ways by both participating institutions and others, nationally and internationally. The processes developed to consider particular items and PSTs responses to these provide the basis for potentially rich professional learning for mathematics educators at school and tertiary level. Roadshows to bring these outcomes to regional Australia are organised for later 2012, early 2013.

A number of recommendations have been made:

- Teacher preparation courses should intentionally focus on developing pedagogical content knowledge.
- PSTs need to experience both mathematics and pedagogical approaches across all strands of the mathematics curriculum.
- Efforts should be made by Faculties and Schools of Education to recruit and develop continuing staff in mathematics education.
- Mathematics educators should engage in ongoing professional learning and appropriate induction programs.
- Universities should work to develop a common language to describe the components of initial teacher education courses.
- Benchmarking exercises should be established within and among universities to monitor the on-going development of mathematics education outcomes.

In many ways the CEMENT project is ongoing. A communiqué from the final conference is being prepared and will be disseminated to all teacher education providers. Other outcomes from the CEMENT project include:

- Instruments to measure PSTs' knowledge and beliefs about mathematics, and their PCK at primary and secondary levels. (See Appendices A and B.)
- A version of these instruments that is suitable for mathematics educators, and teachers.
- A process for professional learning based on PSTs' responses to items, as well as the items themselves.
- An increased awareness of professional attributes aligned with PCK that could be applied to the development of professional courses within tertiary institutions.
- One institution has already chosen to utilise CEMENT project data to monitor progress on the implementation of a new degree structure being implemented from 2012.
- All partner institutions are engaged in some level of change informed by CEMENT, ranging from continuing discussions, holding workshops, using the instruments to review course units and inform their development, through to providing a common language and processes to discuss these teaching matters, and initiating collaboration between campuses, faculties and across institutions.

The instruments are already in the public domain, and are included in the appendices of this report. The online version may be accessed through the survey software by applying to the University of Tasmania (education.research@utas.edu.au) for a secure link, and arrangements will be made to forward the initial findings to anyone who chooses to use the instruments in this way.

Ongoing work is possible using these instruments and processes. In particular, it would be possible to undertake a technical study to link the CEMENT findings with those of TEDS-M to provide international benchmarks. This report has only addressed primary pre-service teachers but data are now available from secondary PSTs as well, and these will be analysed and disseminated widely in the near future.

The CEMENT project has provided a unique opportunity to develop processes and instruments to provide a solid evidence base for improvement of mathematics education in initial teacher education courses. The project has made a lasting impact in the participating institutions. It has attracted interest nationally and internationally because of the innovative approach and the attempts to measure beyond mathematics content. The processes could be used in other areas of teacher education, such as literacy, and in other professional preparation courses, such as nursing. In addition, there is potential to develop induction practices for new tertiary educators. In short, it appears that this project has provided useful information that can impact on future practices in a variety of ways.

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Chapter 1: Background

This project aimed to provide a process for providing evidence about the quality of pre-service teachers' (PSTs) outcomes in mathematics education in ways that would allow universities to improve their provision of mathematics education.

Ongoing and increasingly alarming calls for urgent action to address the shortage of mathematics teachers and improve the quality of mathematics teaching in Australia make the focus on mathematics teacher education crucial. In international studies, Australia has slipped in rankings over the period 1995 to 2007, especially at the Year 8 level where it is now outperformed significantly by the United States and England (Australian Council for Educational Research, 2009). The declining rates of participation in high level mathematics courses at Year 12 are threatening the nation's economic expansion with official estimates predicting a growth rate of 3.5% annually in demand for mathematics and statistics graduates (Brown, 2009) which is unlikely to be met. Recent figures suggest that although participation in mathematics at Year 12 is high at around 90%, rates of uptake of top level courses has declined from 13.9 % of Year 12 students in 2001 to 11.6% in 2007 whereas in the lowest level courses participation rates over the same period rose from 42.3% to 46.4% (Ainley, Kos & Nicholas, 2008). Many teachers are teaching mathematics without a strong mathematical background (Brown, 2009; Human Capital Working Group, Council of Australian Governments (COAG), 2008; Thomas, 2000; Thomson & Fleming, 2004) and in view of the falling participation rates in high levels of mathematics, this is likely to continue.

This worrying situation provided the background to this project with the aims of:

1. developing instruments to measure the outcomes of teacher education programs in mathematics in terms of mathematical understanding, appropriate pedagogical knowledge, and attitudes and beliefs about mathematics;
2. generating approaches to support lecturers in making changes to their teaching practice, informed by the data collected;
3. supplying data-driven evidence about effective models of teacher education in mathematics on which course changes could be based; and
4. disseminating findings widely to engage the teacher education and the mathematics and statistics communities in a culture of evidence-based course development for pre-service teachers.

This collaborative project involved seven universities in most Australian states and territories: The University of Queensland (QLD), The University of Melbourne (VIC), The University of New England (NSW), Flinders University (SA), Murdoch University (WA), Charles Darwin University (NT) and the University of Tasmania (TAS) (lead). Using instruments developed by the project team, participating institutions collected data about their pre-service teachers' outcomes at a point during their course that would provide data to teacher educators that would be useful in driving improvement.

Within the participating institutions, the mathematics education teams considered the data and the ways in which they might change their practice at both individual and team level. Findings were shared with other teacher education staff, within and beyond the participating universities. In this report, details of the processes and practices that both aided and impeded the project's progress are reported.

The structure of this report is as follows:

- Chapter 2 provides a theoretical background to the project.
- Chapter 3 details the process of instrument development, and in particular the decision making processes around choosing both what to measure and how to measure it.
- Chapter 4 reports the findings from the project including useful models of teacher education in mathematics;
- Chapter 5 describes the wide dissemination of the findings and ways in which the instruments developed are being used. It also suggests potential future work and improvements that could inform the next wave of evidence-based change processes.

Chapter 2: Relevant Literature

The project was underpinned by a strong conceptual framework and sound measurement principles. Each of these aspects is described, supported by relevant literature from national and international sources.

Conceptual Framework

Outcomes of teacher education programs are rarely considered in the same way that student outcomes from schooling are examined. There are continuing calls for improvement of teacher education but little evidence exists for the superiority of one model of teacher education over another. Discussion papers, such as *Great Teaching, Inspired Learning* (http://www.schools.nsw.edu.au/news/greatteaching/initial-teacheredu/index.php) from the NSW government illuminate the current situation and pose a number of questions for consideration, including aspects of pre-service teachers' backgrounds, practicum supervision and the quality of teacher educators. The evidence base for changes and improvements in initial teacher education provision is, however, very limited.

It seems sensible to suppose that pre-service teachers' outcomes are likely to be influenced by similar factors to those impacting on schools. These factors include institutional level factors as well as student characteristics. The conceptual framework on which this project was based was adopted by the international Teacher Education and Development Study in Mathematics (TEDS-M) (Tatto, Schwille, Senk, Ingvarson, Peck & Rowley, 2008). Although Australia contributed to the development of the instruments and the conceptual framework, Australian teacher education institutions did not participate in the study itself.

The conceptual framework for TEDS-M included three domains: Characteristics of Future Teachers, Characteristics of Teacher Educators, and Characteristics of Teacher Education Programs (Tatto et al., 2008). These domains are deemed to be interrelated yet act independently on outcomes of teacher education programs against a background of policy and practice unique to the place of education. The same domains are relevant in Australia. The broad policy framework in which Australian mathematics educators operate, however, is similar across the nation i.e., National Standards for Teaching (AITSL, 2011) and the Australian National Curriculum (ACARA, 2012) hence this aspect was not included in the model used. The conceptual model that formed the basis of the CEMENT project is shown in Figure 2.1. The sections following the figure explain each aspect of the framework for this project.

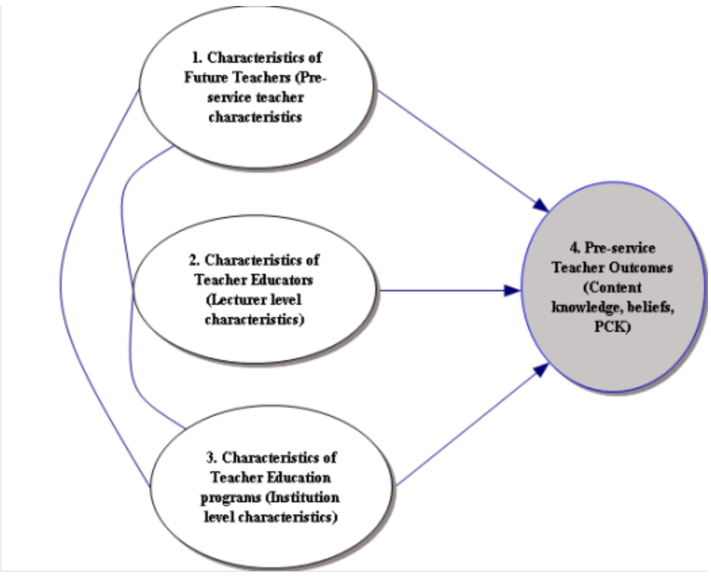

Figure 2.1: CEMENT Conceptual Framework

<u>1. Characteristics of future teachers</u>. Background information such as previous professional experience, age, gender, location, qualifications, study experiences, attitudes to and beliefs about mathematics and mathematics learning (including about themselves as mathematics learners) might impact on pre-service teachers in a variety of ways. Many primary pre-service teachers enter their university courses with very negative and even fearful attitudes to mathematics (Beswick, 2006; Brown, 2009), and with weak mathematical knowledge (Brown, 2009; Mays, 2005).

<u>2. Characteristics of teacher educators</u>. Teachers in classrooms influence school students'

outcomes (e.g., Hill, Rowe, Holmes-Smith, & Russell, 1996), and the same is true of the influence of tertiary educators on tertiary students' outcomes (Biggs, 2003). Hence considerations such as the backgrounds of teacher educators, recency of classroom experience, tenure of position, qualifications and so on were considered for a model addressing pre-service teacher outcomes. Also relevant were lecturers' beliefs on mathematics, mathematics teaching and learning, and the needs and capacities of the pre-service teachers with whom they work.

3. Characteristics of teacher education programmes. In addition to the nature of the mode of delivery and level (e.g., undergraduate or post-graduate entry) there are less easily identified organisational constraints which could also impact on outcomes such as: the number of mathematics education units experienced, who delivers these (Education or Mathematics lecturers), and when they are located in the course; the organisational arrangements within the institution such as the nature of the faculty or school and multi-campus arrangements as well as the growing emphasis on distance and online learning. Teachers tend to teach as they were taught (Ball, 1990), and they attach great importance to their experiences in schools (Beswick, 2006; Richardson, 1996). Hence, the place of the practicum in relation to mathematics education units, and the manner and extent to which these experiences are integrated into the university-based elements of programs were also important elements of this aspect of the conceptual framework.

4. Pre-service teacher outcomes. Mays (2005) found that a surprising proportion of Australian pre-service primary teachers had difficulty with mathematical content at about Year 8 curriculum level. At the secondary level, mathematical knowledge is generally assumed from the academic backgrounds of pre-service teachers. It is known, however, that an increasing number of "out-of-area" teachers are teaching in secondary mathematics classrooms with limited pre-service education in mathematics (Brown, 2009; Australian Council of Deans of Science, 2006; Human Capital Working Group, Council of Australian Governments, 2008). The CEMENT project provided tools to establish the mathematics content knowledge of pre-service teachers in courses from which many of the "out-of-area" teachers are recruited, such as science and physical education.

One challenge in using a framework of this type is to identify exactly what should be measured. Background characteristics are relatively straightforward to collect but issues around the nature of teachers' specialised understanding of mathematics are more contentious.

Teachers' Mathematical Knowledge

It is recognised that teachers of mathematics require more than just content knowledge. Shulman's (1987) seminal work identified seven knowledge-types considered important for teachers: (i) content knowledge; (ii) general pedagogical knowledge; (iii) curriculum knowledge; (iv) pedagogical content knowledge (PCK); (v) knowledge of learners and their characteristics; (vi) knowledge of education contexts; and (vii) knowledge of education ends, purposes, and values (p.8). In the intervening years, there has been considerable progress in identifying the nature of the knowledge that teachers of mathematics need. Ma (1999), for example, described "Profound Understanding of Fundamental Mathematics" (p. 22). Even and Tirosh (2002) emphasised the importance of teachers' knowledge of their students' mathematical learning. Hill, Rowan and Ball (2005) described Mathematical Knowledge for Teaching which they described as that "… mathematical knowledge used to carry out the *work of teaching mathematics*" (p. 373, italics in the original) including providing examples, explaining concepts, correcting work and using a range of representations of mathematical ideas. Chick, Baker, Pham, and Cheng (2006) provided a useful framework in which teachers' classroom actions were characterised as *Content Knowledge in a Pedagogical Framework,* such as demonstrating a method for solving a mathematical problem; *Pedagogical Knowledge in a Content Context*, such as using a process for engaging students in the mathematics; and *Clearly PCK*, which included aspects such as choosing an appropriate representation or model to exemplify the mathematics. These attempts aimed to describe teachers' specialised mathematical knowledge as it is used for teaching.

Attempts to linking teachers' knowledge to students' mathematical outcomes have been somewhat mixed. Mewborn (2001) indicated that measures of courses taken or similar de facto measures of teachers' mathematical content knowledge had little relationship with students' learning. Direct measures of mathematics content knowledge, such as tests of high school mathematics with primary teachers, however, have been shown to be associated with gains in students' mathematics learning (Harbison & Hanushek, 1992; Mullens, Murnane & Willett, 1996; Rowan, Chiang & Miller, 1997). It seems that teachers need deeply connected content knowledge to draw on in classrooms, but that this understanding may not be related just to quantity of mathematics courses taken.

There have been a number of qualitative studies that show that it is the specialised ways in which teachers understand mathematics that are important. There are many studies that suggest that having a deep knowledge of the mathematics content does not guarantee that teachers can provide rich learning experiences for their students (e.g., Ball, 1991; Eisenhart et al., 1993; Schoenfeld, 1998; Schoenfeld, Minstrell, & van Zee, 2000). The role of initial teacher education should be to develop the kind of mathematical knowledge that is useful in classrooms so that teachers can influence their students' learning outcomes.

Hence, teachers' specialised mathematical knowledge comprises both mathematics content knowledge, that is, understanding the necessary mathematics beyond the immediate demands of the curriculum, and pedagogical content knowledge, that is, the complex blend of content and pedagogical knowledge that provides the basis for classroom decisions made on a day-to-day basis.

Measuring Teachers' Knowledge

One issue surrounding the links between teachers' knowledge and their students' learning outcomes has been the difficulty of measuring teachers' knowledge. Hill, Schilling and Ball (2004) developed measures of elementary teachers' "mathematical knowledge for teaching". They used a multiple choice instrument that included a number of questions that Chick et al (2006) might have characterised as "content knowledge in a pedagogical context" rather than PCK. Callingham and Watson (2011), working in statistics, provided measures based on teachers' predictions of students' responses to statistical questions, and their proposed interventions. The items were coded using a hierarchical rubric based on the increasing complexity of teachers' responses. This instrument was based on an earlier profile instrument (Watson, 2001), and provided a reliable and valid scale of teachers' statistical pedagogical content knowledge. Baumert et al (2010) used instruments aligned to the German system to measure secondary teachers' content knowledge and PCK in mathematics. Their PCK items included some related to *tasks*, that is, identifying a range of appropriate solutions, similar to some of the Callingham and Watson items. The second domain of PCK used by Baumert et al was *students,* addressing teachers' competence in identifying common student misunderstandings. The final component was *instruction,* which identified ways in which teachers' might represent or explain standard mathematical ideas. These items were scored using a partial credit approach. The TEDS-M study (Tatto et al, 2008) also developed measures of pedagogical content knowledge that were used with pre-service teachers. These items were mainly multiple choice or short answer with some recognition of partially correct responses, and many had similarities to the items used in CEMENT.

The CEMENT project was undertaken at a period when there was considerable interest in measuring teachers' knowledge, at both initial teacher education level, as in TEDS-M, and for practising teachers. Despite this activity, however, it has proved much more difficult to identify strong associations between teachers' knowledge and students' outcomes, although the association appears stronger when PCK or similar measures are used. For example, Hill, Rowan and Ball (2005), using their measures of teachers' mathematical knowledge for teaching, found that teachers' knowledge was significantly related to student achievement in lower primary classes, using a linear mixed-model approach. Also using sophisticated analytical techniques, multi-level structural equation models, Baumert et at (2010) identified PCK as having a large effect on students' learning outcomes, although mediated by classroom practices. It seems that where associations between teacher knowledge and students' outcomes has been identified, it is the more complex forms of specialised mathematical knowledge such as PCK that has an impact, beyond measures of mathematical understanding. The efforts to measure PCK, therefore appear to be justified.

Initial findings from the TEDS-M project also show differences between mathematics content knowledge and PCK, again using multi-level models. Whereas mathematics content knowledge was affected by student intake background, PCK was not. In addition, opportunity to learn mathematics during the initial teacher education course was an important predictor of outcomes, although this was mediated by student background. Students with higher reported mathematics backgrounds tended to enter courses that provided more opportunity to learn mathematics (Blömecke, Suhl, Kaiser & Döhrmann, 2011). TEDS-M researchers were also challenged by the wide variety of educational systems and courses that made direct comparisons difficult (Tatto, Senk, Rowley, & Peck, 2011). In the light of these findings, some aspects of the CEMENT project are particularly pertinent.

The next chapter describes the approach taken by the project, including the development of instruments and the data collection processes.

Chapter 3: Approach

The aim of the CEMENT project was to develop processes by which participating universities could identify strengths and weaknesses in their initial teacher education courses based on sound and defensible data. To this end, a key aspect of the study was to develop suitable instruments. The process of identifying what to measure, and the development of appropriate items, is described in some detail because the discussions around this aspect proved to be very fruitful. The ways in which data were collected and analysed, and the dissemination of findings to participating institutions and beyond are also provided.

Project Meetings

The CEMENT project began with an initial meeting of project partners at the 2010 annual conference of the Mathematics Education Research Group of Australasia (MERGA). This meeting was simply to establish initial protocols and begin considerations about instrument development and data collection.

The first key meeting of the team was held about one month later in Melbourne, and took the form of a two-day residential seminar. The main task was to decide what information was needed and how to collect this. The data had to be useful to participating institutions but also provide a sound basis for providing comparisons and models of influences on teacher education. In addition, it had to be collected through a process that required minimum interactions with the academics concerned, and did not need extensive transcription or data entry. Practically, this limited the kinds of data that could be collected to item formats that could be delivered through web-based tools and machine scored. The decision was made, however, to collect additional interview data from pre-service teachers (PSTs) who volunteered, to add depth to the information gathered.

A number of administrative decisions were taken that aided the smooth flow of the project. At this point a Project Manager (PM) had not been appointed but it was agreed that, when the appointment was made that the PM would be the hub for communication. A teleconference was arranged as a follow up to the meeting.

Protocols were also agreed for publishing, including appropriate acknowledgement of funding. To reduce any concerns about attribution of authorship, it was agreed that all publications relating to the project overall would include all team members, with a lead author and then alphabetically, and that any publications relating to specific universities would be published under the relevant team members' names only. This arrangement ensured that there were no arguments around publications.

Several members of the team were coincidentally involved in another national project funded through the Australian Association of Mathematics Teachers (AAMT). As a result, CEMENT was able to leverage off that project and "piggy back" additional face-to-face meetings that had not been included in the initial planning. As a result a meeting was held in Brisbane in March 2011, and Sydney in March 2012. These meetings proved invaluable in a number of ways and did provide the opportunity to maximise the effectiveness of the project.

At the meetings there was considerable discussion about what information was needed and how this might be disseminated and used within and between universities. There was general agreement that a focus on mathematics content alone was not sufficient, although it was recognised as important and needed to be one component of the data collection. In addition, an attempt was needed to measure PCK. There was considerable discussion around the nature of the various instruments available at the time, or for which there were some publicly accessible items. None of the materials to which there was access captured clearly what the team identified as important, so the decision was made to develop a new instrument. This instrument also included a section on the beliefs of pre-service teachers about mathematics and its teaching, as well as extensive demographics. The process of instrument development is described in the next section.

Instrument development and delivery

Deciding on the nature and types of items that would form the measures that could inform participating universities about their students and programs proved to be both the most challenging and rewarding aspect of the project. As indicated in the literature review, there were a number of conceptions of the nature of mathematics for teaching. The CEMENT team made an initial decision that they wished to have information about both mathematics content knowledge and PCK. Mathematics content knowledge was conceived of as the kind of knowledge that either a primary or secondary teacher respectively might need to draw on in the classroom, and did include some aspects of Chick et al's (2006) notion of "content knowledge in a pedagogical context". For PCK, a decision emerged to focus on aspects of Chick's (2007) detailed framework and the approach taken by Callingham & Watson (2011), including representations, responding to students and identifying appropriate intervention. For both mathematics content and PCK, questions were needed that addressed all aspects of the content strands of the *Australian Curriculum – Mathematics* (ACARA, 2012). This statement does not capture the richness and quality of the discussion, and the ways in which everybody concerned was challenged in their thinking. The openness and the robustness of the debate, together with a very strong collegiality, became the hallmarks of the project.

For practical reasons, it was decided that the instruments used would be made available online through Qualtrics survey software (www.qualtrics.com) and that they would be formats that could be machine scored. This decision left a limited variety of item formats, including multiple choice, true/false or Likert scale. There were also time constraints: it was not thought likely that Pre-service Teachers (PSTs) would respond to an instrument that was time-consuming. The specification for the PST survey was decided as 10 Beliefs items developed from existing literature; 10 Mathematics Content Knowledge items (MCK) and 10 PCK items, in addition to the demographic questions, to create a survey that could be completed in no more than one hour. The MCK and PCK items were to be drawn from a larger pool of items that would be randomised.

It was impossible to develop items fully in the time available at the initial meeting, although some items were written at that time. Instead a framework for item development was created (see Table 1) and the responsibility for writing items was shared among the team.

Table 1: Framework for CEMENT survey development

PCK Items	**Identifying errors and student thinking**	**Affordances of stimulus materials**	**Different representations of mathematical concepts**	**Explaining mathematical ideas**
Primary and secondary PST	All curriculum strands	All curriculum strands	All curriculum strands	All curriculum strands
MCK Items	**Conceptual understanding**	**Procedural understanding**	**Skills**	
Primary and secondary PST	All curriculum strands	All curriculum strands	All curriculum strands	
Beliefs	**Confidence to teach mathematics**	**Beliefs about mathematics**	**Beliefs about teaching mathematics**	

Extensive demographic information was also sought, and this proved to be surprisingly difficult. Across the seven universities, there was a very wide variety of terminology, types of course, modes of delivery and entrance requirements. For the PST survey, it was decided that the best way to handle this was to create a single survey with a number of logic statements relating to particular institutions. In that way, PSTs could respond accurately to questions about their courses and the quality of data would be improved. In addition, although the target demographic was PSTs at the end of their course, the team decided to make the survey openly available because of the variety of opportunities that team members had to talk to students about the survey. A question was included about when the respondents aimed to graduate as a de facto measure of how far they were from completing their course.

A follow up teleconference provided a pool of agreed items. These were put into appropriate formats online and piloted with PSTs at the University of Tasmania over summer semester 2010/2011 (Beswick & Callingham, 2011; Callingham & Beswick, 2011).

Ethics approval for the project was obtained from the University of Tasmania (H11464). The other participating institutions then went through their own ethics processes as required so that they could use the data.

The CEMENT team had a further two-day meeting in Brisbane in March 2011. At this meeting the key focus was refining and improving the instruments based on the pilot data collected over summer. Again the discussion was challenging and deep, to such an extent that the team decided to present some of the items that caused the greatest debate at the joint AAMT/MERGA conference in Alice Springs, July 2011 (Callingham et al, 2011) along with some of the early findings from the pilot study. A decision was also taken to broaden the audience by applying for a symposium at the 2011 conference of the Australian Association for Research in Education (AARE) (Beswick & Callingham, 2011; Chick, 2011) and presenting a more technical paper about the analysis of the data (Callingham & Beswick, 2011).

The final agreed survey was released through a web link to all participating universities. Individual team members emailed the information sheet about the project and the web link to their students, choosing the cohort that would be of the most use to them. Participation was voluntary and anonymous, unless the PSTs chose to indicate that they would be willing to participate in an interview, or that they wished to go into a draw for an iPod Touch™, that was included as an incentive. From the 2011 round of data collection, 344 primary PSTs from all institutions started the survey and valid data were obtained from 294 PSTs. It was notable that the response rate dropped as the questions became more difficult with 294 valid responses to the Beliefs (BLF) items, 212 to the MCK items and 159 to the PCK items. A second round of data collection is being undertaken in 2012 at the request of the participating institutions. Secondary PSTs were more difficult to collect data from, partially because of the lower numbers generally. Eventually responses were received from 100 secondary PSTs, providing 83 valid responses to the BLF items and 53 valid responses to the MCK and the PCK items. Results from these surveys are reported in the next chapter.

A survey was also created for the mathematics educators at the participating institutions. This used the same item sets as the PST surveys but had different demographic information, including experience in classroom teaching, the nature of the appointment and mathematics background. Some universities found it difficult to get lecturers to participate, especially casual or part-time staff, and only 30 responses were obtained.

The instruments used for Primary and Secondary PSTs are provided in Appendices B and C.

Additional Data Collection

Following a presentation at the AAMT/MERGA conference, a number of MERGA members expressed interest in looking at the survey so an invitation was extended to make the lecturer survey available to any members who wished to participate. The survey was made available from the MERGA webpage. A further 57 mathematics educators completed the survey and these results were pooled with those received from mathematics educators in the participating institutions. These combined files provided valid responses from 53 respondents, and were reported to MERGA members at the MERGA conference in 2012

(Callingham, Beswick, Clark, Kissane, Serow, & Thornton, 2012).

Interest also came from practising teachers. As a result, the mathematics educators' survey was modified slightly, with more appropriate demographic information and is currently available as a link from the AAMT website (www.aamt.edu.au).

The additional information that will come from these extensions to the project will provide valuable information to the profession and to universities about the experience and skill of current and potential mathematics educators, in relation to their students. The data are still being analysed.

In addition, many of the project members wanted to survey more students to improve the information that they had gained from the initial survey. Secondary pre-service teachers were particularly hard to contact because there are small numbers and many are studying part-time at distance. Hence there was a push to collect additional data specifically targeting secondary pre-service teachers. These data are still being collected and surveys will remain available until the end of the academic year in 2012.

Dissemination Strategies

A final CEMENT project meeting was held in March 2012, again capitalising on project members' involvement with another project. The key discussion at this meeting was the final CEMENT conference that was part of the initial project planning, and other dissemination strategies.

In addition to the conference, a decision was made to reach out to regional universities because these were often neglected in dissemination strategies. From the MERGA/AAMT conference it was evident that bringing teachers and teacher educators together provided potentially useful links and rich conversations about outcomes of teacher education programs. From this basis, it was decided to use processes developed in the project to create opportunities for these groups, as well as interested scientists and mathematicians from local universities, to discuss the nature of mathematics teaching and teachers' knowledge. These sessions are planned for late 2012 and early 2013 to fit with both school terms and the tertiary academic year.

The final CEMENT conference was a two day intensive workshop. The program is attached in Appendix C. In addition to academics from several universities, current undergraduate students and Year 11 high school students were involved. A video of primary school students using technology to enhance learning was used in order to provide a future orientation and emphasise how tertiary teaching would need to change in response to the range of skills that potential tertiary students are now acquiring. Links were also made to other disciplines with the notion of "clinical acumen" being aligned with the pedagogical content knowledge of teachers. Clinical acumen was introduced by Dr Helen Keates, a lecturer in veterinary anaesthesia. This aspect provided one of the most rewarding discussions of the conference, and suggested new possibilities for tertiary professional courses. As an outcome from the conference, all participants at the conference committed to some action which will lead to a conference communiqué for publication and dissemination early in 2013.

Chapter 4: Findings

In this chapter the findings of the project are presented. These include initial findings from data collection of primary PSTs, influences on primary PSTs' outcomes, draft findings from PST interviews, and data from mathematics educators. In addition, potential further work is explored, as well as the ways in which participating universities and others used the information obtained.

Findings from the Initial Survey of Primary Pre-service Teachers

Demographic information

The initial analyses were undertaken with a sample of 344 pre-service primary teachers from seven universities who responded to the survey. Of these respondents, 294 (85.5%) answered sufficient items to obtain valid measures on at least one variable – several logged on, completed the demographics and then decided not to go further. Of those who did attempt the remainder of the questions, it was noticeable that many answered the beliefs section but then did not attempt the mathematical items.

Of the PSTs who responded, 78% (228/294) were studying full time. Nearly half (45%, 131/293) were studying off campus, and 44% (129/293) on campus. The remaining 11% of PSTs were undertaking some form of blended study with at least part of their degree off campus, showing the changing nature of tertiary study. Most were towards the end of their study period with over half (159/293, 54s%) aiming to finish their degree in 2011 or 2012. Respondents had mainly undertaken a pre-tertiary mathematics course in Year 11 or 12. Less than 10 per cent were from Aboriginal or Torres Strait Islander backgrounds, or spoke another language rather than English at home.

Nearly half of the respondents (132/293, 44.9%) were undertaking a 4-year Bachelor of Education degree with a further third (98/293, 33.3%) doing a combined degree of some kind. Of those undertaking a post-graduate entry qualification, 15.6% (46/293) were studying a 2-year Master of Teaching and only 5.8% (17/293) were taking a 1-year Diploma of Education, reflecting the shift to professional masters level degrees.

Quality of the Instruments

The PST survey was designed to measure a "thick" construct of Mathematical Knowledge for Teaching (MKT), and also to provide information about PSTs on three sub-scales: beliefs about mathematics and its teaching (BLF), mathematics content knowledge (MCK) and pedagogical content knowledge (PCK).

Beliefs items were chosen from various sources to address identified aspects of teachers' beliefs about mathematics and its teaching. They included nine statements requiring respondents to indicate the extent of their agreement to the statement on a 5-point scale from strongly disagree to strongly agree, drawn from those used in previous studies (e.g., Howard, Perry, & Lindsay, 1997; Thompson, 1984; Van Zoest, Jones, & Thornton, 1994). The items were chosen so that three related to each category of beliefs about the nature of mathematics, beliefs about mathematics teaching, and beliefs about mathematics learning. The tenth item asked pre-service teachers to rate on a similar 5-point scale their confidence to teach mathematics at the grade levels that they would be qualified to teach. The final scale was termed BLF.

Item scoring for the MCK and PCK items was mostly dichotomous (right/wrong) but some of the PCK items were scored using a partial credit approach. This was the result of some situations that provided several possible affordances to develop students' understanding and which route the teacher chose could depend on the class, the aim of the lesson, or a variety of other practical considerations. All of the items were original although some were based on modified stimulus material used in other studies conducted by the team.

The items were analysed using Rasch (1960) measurement approaches to create interval level measurement scales. The analysis was performed with Winsteps 3.74.0 software (Linacre, 2012), using the partial credit model (Masters, 1982). Four separate analyses were undertaken. First all items were scaled together to identify a general scale of pre-service teachers Mathematics Knowledge for Teaching (MKT). Then three sub-scales were analysed individually to give a Beliefs scale (BLF), Mathematics Content Knowledge scale (MCK), and Pedagogical Content Knowledge scale (PCK). Scales were examined for overall fit to the model. Person ability measures, in logits which are the units of Rasch measurement, were obtained and used in a variety of comparisons across sub-groups defined by the different demographic information.

Assumptions underpinning the Rasch model include independence of items, and the presence of a uni-dimensional construct. This latter assumption is used to test for construct validity. In Rasch measurement, the key determinant is fit to the model. When items do not fit well, the scale is compromised and construct validity is not able to be inferred. Altogether, four fit measures are produced by the Winsteps program: infit mean square value (infit), a weighted value that is less sensitive to outliers, and outfit mean square value (outfit). Both of these statistics have an ideal value of 1.00, but usual “rule of thumb” values accepted lie between 0.77 and 1.3 (Wright and Masters, 1982). These are also presented as standardised z measures, having an ideal value of 0.00, and acceptable fit is between ±2. These values are all considered when considering the quality of items that comprise an instrument. Where items fit well, it can be inferred that the basic assumptions of the Rasch model are met and that the items work together in a consistent fashion to measure a single, uni-dimensional construct.

MKT Scale. The overall scale consisted of 82 items, comprising 10 BLF (beliefs) items, 45 MCK (content) items and 29 PCK items. Summary fit statistics for this scale for persons and items are shown in Table 3. The Cronbach alpha reliability was high at 0.89. The overall fit to the Rasch model was good for both items and persons suggesting that the instrument provided satisfactory measures of pre-service primary teachers Mathematics Knowledge for Teaching (MKT). This is a “thick” construct comprising sub strands of BLF, MCK and PCK.

Table 2: Summary statistics for items and persons for the MKT scale

	N	Mean (logits)	Infit	*z* Infit	Outfit	*z* Outfit
Items	82	0.00	1.00	0.00	1.00	0.00
Persons	212	0.22	1.00	0.00	0.98	-0.1

Subscales: BLF, MCK, PCK. Of the 43 MCK measured items, only two showed any degree of misfit and in both instances this was very small. Using the suggested “rule of thumb” limits of infit and outfit lying between 0.77 and 1.3, these items would fit the model. Among the 29 PCK items, only one showed any misfit and again that was small and would meet the criteria suggested by Wright and Masters (1982). This was an item about useful resources to develop young children’s subitising (recognition without counting of small numbers in a collection).

Summary statistics for all three subscales are shown in Table 3. The Cronbach alpha reliabilities were relatively low for the MCK and PCK scales, probably because of the amount of missing data caused by the random presentation of the items. Overall, it appeared that the instruments could provide reasonable measures that universities could use for monitoring purposes.

Table 3: Summary statistics for items and persons for the three subscales

Scale	N_I	N_P	$Mean_I$	$Mean_P$	$Infit_I$	$zInfit_P$	$Outfit_I$	$zOutfit_I$	$Infit_P$	$zInfit_P$	$Outfit_P$	$zOutfit_P$	Cr α
BLF	10	294	0.00	0.77	1.00	0.00	1.00	0.00	1.01	0.00	1.00	0.00	0.86
MCK	43	212	0.00	0.32	1.01	0.10	0.99	0.10	0.96	-0.10	0.93	0.00	0.64
PCK	29	159	0.00	-0.18	1.00	0.00	1.00	0.10	0.97	-0.10	0.98	0.00	0.65

Note: Subscript I indicates items, P indicates persons.

Patterns of Response

Using the person measures, the overall pattern of responses was considered. Figure 3.1 shows the distributions of responses on all three scales. The BLF scale showed the highest measures, with a contracted range, suggesting that the primary PSTs who responded to these items found it easy to endorse them and that there was little variation in their responses. The MCK scale was harder, and the distribution suggests that although there were some PSTs who achieved well on the mathematical content, there were clearly some who struggled with mathematical questions. The most difficult scale, showing the lowest achievement measures was the PCK scale. In particular, this scale has a long tail of low achievers, indicating that this is the area of greatest weakness. Similar patterns were found in the pilot data (Callingham et al, 2011) and have also been identified in other similar data (Beswick, Callingham & Watson, 2011).

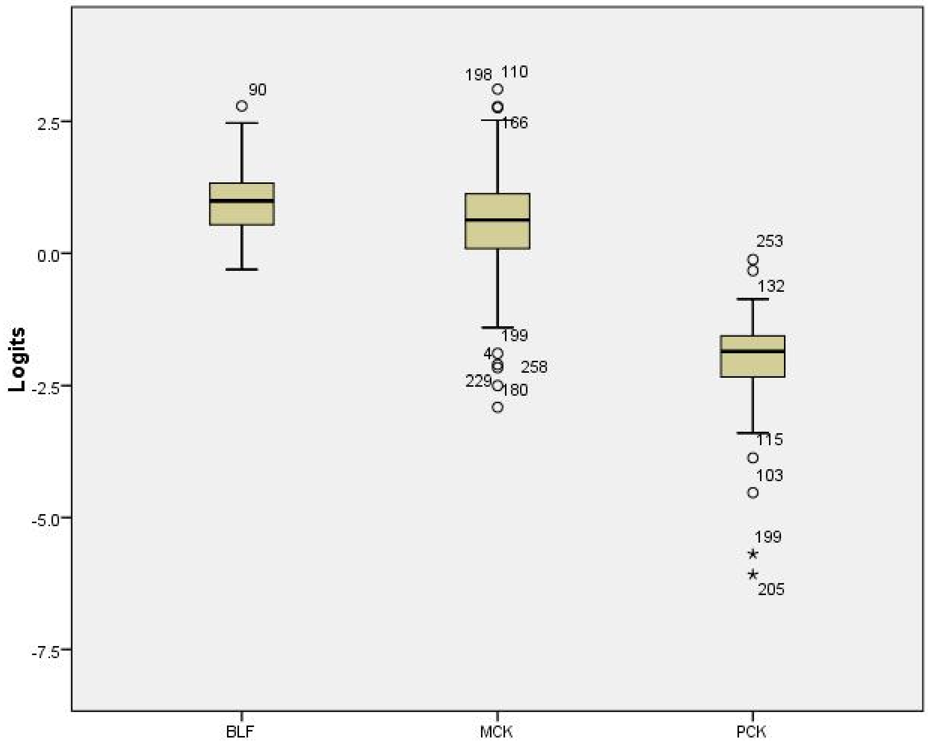

Figure 3.1: Distribution of logit scores on each of the 3 scales

Differences between groups

Mean differences were examined for the various independent variables using *t*-tests or Analysis of Variance (ANOVA) as appropriate. In general there were no statistically significant differences among any groups for BLF, other than for PSTs who came from a non-English speaking background (NESB). Those 26 PSTs who did not speak English as their mother tongue had significantly more positive beliefs about mathematics and its teaching (t = 2.294, df = 292, p = 0.022). The small number of NESB respondents, however, suggests that this finding should be treated with caution.

For MCK, however, there were significant differences for mode of study with students off-campus doing significantly better than those studying on-campus or by mixed mode (F = 5.31, df = 2, p = .006), and for highest level of mathematics studied (F = 4.34. df = 6, $p < .001$). Somewhat counter-intuitively, the group achieving best on the MCK scale were not those who had studied mathematics as part of a bachelor degree, but were those who had studied the highest level of pre-tertiary mathematics (maths specialist) at Year 12. It may be that recency of experience was playing a part with those who had studied mathematics in an earlier degree not as familiar with "school maths" as those who had taken Year 12 mathematics immediately prior to beginning an education degree. The general level of educational background, however, did not produce statistically significant differences on any of the scales. The nature of the course also showed significant differences (F = 4.36, df = 3, p = .005), due to the difference between those taking the 1-year Diploma of Education (DipEd) and respondents from the combined degrees (e.g., BA/BEd) and Bachelor of Education (BEd) degrees. This finding is most likely because one participating university offered a generic diploma level qualification which did not separate potential high school teachers, including those who might become mathematics specialists, from primary school teachers. There were only 17 PSTs undertaking the diploma course so these results should be treated with caution.

For PCK, the only significant difference was indigenous status. Those PSTs who appeared to be furthest from graduation (that is early on in their degree programs) had lower achievement on the PCK scale than other groups that was close to statistical significance (F = 2.22, df = 4, p = .07). These findings are consistent with early findings from the TEDS-M study in which opportunity to learn appeared to impact on PCK, whereas self-reported general school achievement predicted content knowledge success (Blömecke et al, 2012). It appears that PCK develops over time during a teacher education course, in contrast to MCK which is influenced by prior knowledge. Students who identified as Aboriginal or Torres Strait Islander people showed significantly lower achievement on the PCK scale (t = 3.06, df = 157, p = .003). This result, however, should be treated with extreme caution because only two PSTs who answered the PCK items identified in this way and it should not be treated as educationally important.

Predictors of Outcomes

A series of stepwise regression analyses were undertaken using each of the three outcome measures, BLF, MCK and PCK, as the dependent variable. Because of the small numbers involved, NESB and indigenous status were not included as potential predictor variables. Each of the outcome variables, BLF, PCK and MCK, was also included into the modelling as potential predictor variables. Not unexpectedly from the previous results, the only significant predictor of PCK was MCK, β = 0.37, t = 4.89, $p < .001$. MCK also explained a small proportion of the variance in PCK, R^2 = .13, $F(1, 156)$ = 23.95, $p < .001$.

MCK was also the only significant predictor of BLF, β = 0.21, t = 2.61, p = .01, explaining a small proportion of the variance in BLF, R^2 = .04, $F(1, 156)$ = 6.85, p = .01. There were more complex outcomes when MCK was the dependent variable. Significant predictors of MCK were BLF and PCK, but also prior mathematics experience (MATHLEVEL) (Table 4).

Table 4: Summary statistics for significant predictors of MCK

	β	*t*	*p*
PCK	.36	4.97	<.001
BLF	.18	2.45	.015
MATHLEVEL	.18	2.44	.016

This model, with PCK, BLF and MATHLEVEL as predictors, explained a small proportion of the variance in MCK, R^2 = .19, $F(3, 154) = 13.19$, p = < .001.

These findings suggest that PCK and MCK are synergistic, with each being significantly related to each other, with educationally important implications. The influence of MCK on beliefs is weak, although statistically significant, and similar comments apply to the influence of BLF and MATHLEVEL as predictors of MCK.

Implications for Primary Pre-service Teacher Education from Student Findings

There are implications from these findings for universities. First, it is clear that mathematics knowledge is important and that pre-service teachers should undertake a pre-tertiary mathematics course or equivalent. Content knowledge alone is not, however, enough. The close relationship between PCK and MCK indicates that attention must be paid to pedagogical content knowledge during teacher education. Prior mathematics learning was not a predictor of PCK; rather PCK appears to develop over time and pre-service teacher education courses need to provide opportunities to learn about the pedagogical aspects of teaching mathematics. As a strong predictor of MCK, developing PCK will also help to develop mathematical understanding. Approaches that privilege MCK over PCK, or vice versa, are likely to lead to less well developed teachers.

Because it appears that PCK requires time to develop, longer courses appear to be important, at least for PSTs intending to enter primary and early childhood education. As yet results are not available for PSTs intending to enter secondary education. Although course type and time to graduation were not significant predictors of PCK, here were significant differences on mean outcomes.

It also appears to make little difference on the measures presented here how students study. Distance students appeared to achieve as well as those on campus, indeed on MCK they achieved at a higher level, and whether the study was undertaken part-time or full-time also made no difference. These findings might provide some alleviation of concerns among teacher educators, but there may be subtle differences among these groups that were not picked up by the instruments used in this study. In particular, the development of PCK in PSTs studying off-campus from university needs further investigation because they are unable to benefit from the modelling of good practice that is possible in on-campus teaching.

A similar set of analyses will be undertaken with data from the secondary PST survey. Because there was a major effort to collect these data in 2012, to improve the number of respondents, the data were not complete in time for this report. The outcomes will be published in a variety of places, and included in a report sent to the ACDE.

Characteristics of Teacher Educators

The data for this analysis was taken from a combined data set from lecturers within project institutions and MERGA members who chose to respond to the survey, to provide sufficient data for analysis. Some details were presented at the MERGA conference in 2012 (Callingham et al, 2012). Items for both MCK and PCK were taken from both primary and secondary pre-service surveys, linked through common items presented to all respondents. The data set used for analysis is shown in Table 5.

Table 5: Data set used for lecturer survey analyses

Scale	Number of respondents	Number of items	Number of link items
BLF	57	10	10
MCK	40	43	21
PCK	44	60	9

Note: Taken from Callingham et al, 2012.

Of the 50 people who responded to questions about the nature of their employment (Continuing, Fixed Term Contract, Casual) nearly half (23/50; 46%) had continuing appointments. The rest were nearly evenly divided between Fixed Term Contract (13/50; 26%) and Casual (14/50; 28%). Among those who had Continuing positions, 15/23 (65%) were at senior lecturer or associate professor level. None were at Level A (Associate lecturer); the remaining eight persons (8/23; 35%) were at lecturer level (Level B). Only two full professors (Level E) responded and they both indicated casual employment, probably because they had retired and were undertaking some adjunct work. Among the mathematics educators who had Fixed Term Contracts, the large majority (11/13; 85%) were employed at lecturer level. When Continuing and Fixed Term Contract respondents are categorised by lower (Level A/B) or higher (Level C/D) the contrast is marked. Table 6 shows the split for these groups of respondents.

Table 6: Breakdown of Fixed Term and Continuing lecturers by level of appointment

	Fixed Term *N*		Continuing *N*	
Lower (Level A/B)	12	60%	8	40%
Higher (Level C/D)	1	6%	15	94%

This difference in level of appointment may reflect the common practice of employing teachers as tutors and lecturers in pre-service teacher education. When Casual employment is considered as well, less than half of the respondents (23/50; 46%) had continuing positions, reflecting the increased casualization of the academic workforce. Nearly 40% of the respondents (22/56; 38%) had taught in schools for more than 15 years, across every state and territory in Australia, and over three-quarters (44/57; 77%) had postgraduate qualifications. Surprisingly, however, nearly one-third (17/57; 30%) had not studied mathematics beyond school level. These are most likely to have been teachers in the primary sector who have moved into academia.

To distinguish the variables from those obtained from the PSTs, the three key measures are given the prefix L (for Lecturer). As with the PSTs, the LPCK items were the most difficult for lecturers, although there was not the monotonic increase in difficulty from LBLF to LMCK to LPCK. Figure 3.2 shows the distributions of the performance on each of the three scales. For mathematics educators the easiest scale was LMCK on which they achieved highly, although there was quite a wide variation. The LBLF scale is characterised by a very narrow range, suggesting that mathematics educators have similar beliefs about mathematics and its teaching.

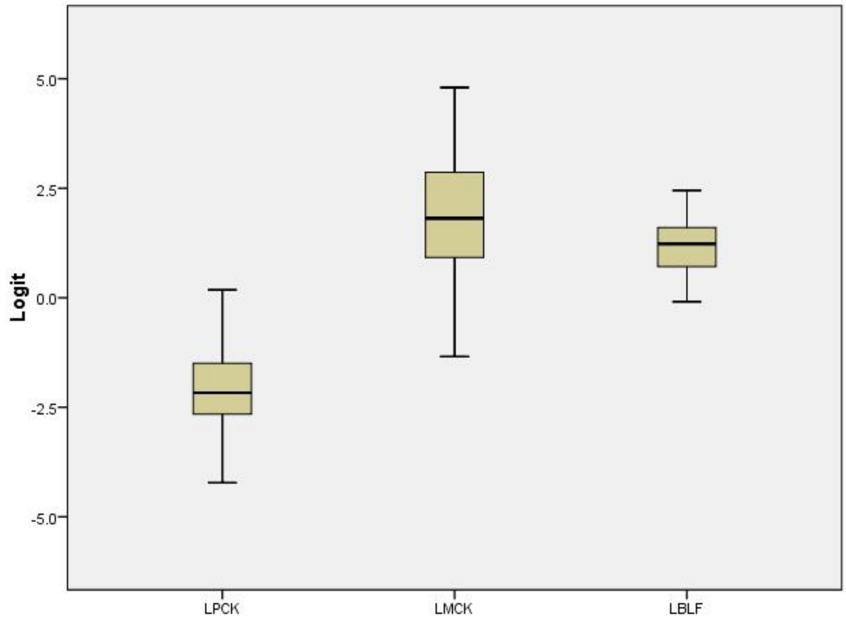

Figure 3.2: Distribution of mathematics educators' logit scores on each of the 3 scales

Of the three variables, LPCK, LMCK and LBLF, only LPCK showed any significant differences. These differences were in favour of full-time lecturers (t = 2.99, df = 42, p = .005), and whether they taught secondary PSTs (t = 4.25, df = 42, p = .000). There was also a significant difference shown in favour of those who did not teach primary PSTs (t = 2.54, df = 42, p = .015), most probably affected by the number of lecturers who taught secondary PSTs. The nature and level of appointment, and years of experience showed no statistically significant differences when an ANOVA analysis was undertaken.

Regression analyses were undertaken in parallel with the PST analyses. LBLF was significantly predicted by only LMCK (β = 0.964, t = 7.664, p < .000). LMCK was significantly predicted by LPCK and the nature of the appointment (β = 1.82, t = 4.099, p < .000) and this model explained a large proportion of the variance in LMCK (R^2 = .41, F(3, 37) = 12.73, p = .001). LPCK showed a more complex model structure. The best model that explained the highest proportion of variance (R^2 = .67, F(4, 35) = 18.30, p < .000) showed LPCK significantly predicted by LMCK, whether the respondents taught secondary (SEC) or primary (PRIM), and the nature of the appointment (APPOINT). The relevant statistics are shown in Table 7. It is worth noting the negative β coefficient for appointment indicating that the more insecure the appointment the lower the LPCK. Similarly teaching primary PSTs also had a negative effect.

Table 7 Regression model predicting LPCK

	Standardised β	*t*	*p*
(Constant)		-2.583	.014
SEC	0.333	3.208	.003
LMCK	0.512	5.082	.000
APPOINT	-0.330	-3.280	.002
PRIM	-0.300	-3.028	.005

To explore this finding further, an analysis of teaching (SEC, PRIM, ECE) against the nature of appointment showed that of the 42 mathematics educators teaching primary PSTs, 22 (53%) were employed on a fixed term contract or casually. In contrast, of the 19 mathematics educators teaching secondary PSTs, only 6 (32%) were employed in this way. For ECE lecturers, the split was similar to the primary, with two-thirds (14/21, 67%) employed on contract or casually. This finding suggests that mathematics educators on continuing appointment were used to teach secondary PSTs first, and that primary PST lecturers were back-filled by non-permanent appointments.

Implications for Pre-service Teacher Education from Lecturer Findings

These findings have important implications for teacher education. The findings that the nature of the appointment, with less permanent staff appointments being a positive predictor of LMCK, are consistent with anecdotal evidence from CEMENT project meetings. Many institutions employ secondary mathematics teachers on a casual or fixed term basis because they are confident with the mathematics. The same group, however, appears to be likely to be teaching primary pre-service teachers and these two factors are negative predictors of LPCK.

Although the mathematics educators' survey results cannot be directly linked to those of the PSTs, the lower outcome from the PCK measure from PSTs may be associated with mathematics educator characteristics. Mathematics education should be seen as a discipline that is more than mathematics alone, and encompasses pedagogical content knowledge appropriate to the intended course. Having mathematics educators in continuing positions appears to provide an opportunity to develop LPCK.

Differences among Institutions

Members of the CEMENT project team completed a questionnaire about the nature of their teacher preparation courses. It was notable that there was no common language to describe the components of teacher education. In some institutions the degree was referred to as a program, in others this was a course. Some universities called the individual components of the degree a course, whereas others referred to these as units. For the sake of clarity, the full degree for teacher preparation will be termed a Course, and the components of that degree will be called Units.

Both undergraduate and graduate intake Courses were taught to PSTs at early childhood, primary and secondary school levels. Undergraduate Courses were all 4-year degrees but postgraduate entry Courses ranged from a 1-year Diploma to a 2-year Master level Course, with a number having an 18-month Master qualification. One university offered a large number of combined degrees such as BA/BEd and one offered only postgraduate entry Masters Courses. Four of the participating universities offered these Courses in both face-to-face and off-campus modes, and three had no off-campus students.

It proved impossible to be able to consider important aspects of Courses, such as the impact of practicum. The placement of practicum components relative to the mathematics education Units varied between institutions and from Course to Course.

With expectations for accreditation for teacher education courses from AITSL, some of the Courses offered were already being considered for revision. Postgraduate entry courses such as Diploma level, will not be suitable for accreditation and there were moves among the CEMENT project partners to revise pre-service courses at both undergraduate and postgraduate level. One institution (Flinders University) implemented the start of a new degree structure in 2012 and will use data from the CEMENT project to monitor progress.

It should be noted that belonging to a particular institution did not appear to impact on students' outcomes, although the amount of data from some project partner universities was too small to make meaningful comparisons.

At the Unit level, there were also differences. The number of mathematics units studied varied from institution to institution, from "part-units" in which mathematics was shared with another subject (often literacy) to three full units of mathematics. In every instance these were termed mathematics curriculum units, and covered more than just mathematical content. The emphases in the units varied, with some universities breaking up the content by curriculum strand (e.g., number and algebra taught in one unit and geometry, measurement and data in another unit) and aiming to develop teaching skills to address the content across all appropriate years of schooling. In others, the emphasis was on developing an increasing understanding of the complexity of teaching mathematics, with a typical sequence moving from the PSTs understanding themselves as mathematics learners, understanding students and the curriculum, to a focus on PCK. In one university, a new mathematics unit was introduced in 2012, taught within the mathematics department and not by education academics. In all other universities all courses were taught by education academics.

The challenge now is to use the findings to improve teacher education. The next chapter describes the work of project universities as they refine and develop their courses.

Chapter 5: Outcomes

A number of positive outcomes have been achieved from the project, and more will flow when the final analyses are updated following the round of data collection in 2012. Projects of this nature take time to become embedded in practice. Discussions about what data to use and how to collect it are not trivial if instruments are wanted to provide useful comparative data for universities. Along the way, however, a number of initiatives have been implemented.

Changes and practices within participating universities

At the University of Tasmania, the pre-service BEd course has three mathematics units. The first unit has a focus predominantly on mathematical content, the second on students and curriculum, and the third and final unit addresses PCK. Following the survey, attention was given to not only overall results but also the content of the outcomes. PSTs generally answered questions with a geometry focus less well than those addressing other content, and similar results were associated with questions having an early number focus. As a result, the mathematics units are being revised. The first unit will include some pedagogical aspects, in line with the finding that both MCK and PCK are important. Early childhood modules are planned for all units, not only for those PSTs who wish to specialise in early years, but for all primary PSTs. All units will include some geometry, and aspects of mathematics from all areas of the curriculum.

In addition, as a direct result of the CEMENT project, staff gained an internal Teaching Development Grant (TDG) to consider their own practice. They are working collaboratively to develop tools and practice to allow them to reflect on their own PCK and what that means for developing PCK in pre-service teachers. The particular challenge is to consider this aspect in relation to off-campus students. The TDG will be completed by March 2013.

At Murdoch University, the project has provided a language and processes that has provided a more collaborative approach to planning and teaching units for primary teacher education courses. A direct outcome of the project included discussions among teaching staff regarding the BLF, MCK and PCK orientations of a sequence of undergraduate units, as well as more engagement in teaching of MCK-focused units by staff previously concerned mostly with later PCK-oriented units. These activities resulted in joint planning of units and valuable discussions regarding teaching and assessment activities at both levels. Discussions about the development of MCK in particular resulted in some joint work on appropriate use of *HOTmaths* (http://www.hotmaths.com.au/), an online learning system intended for schools, resulting in a conference presentation and book chapter. All lecturers attended the CEMENT final conference, and together agreed on plans to undertake the survey and have targeted students at the conclusion of their PCK studies to gather information that will further aid collective planning at all levels, once the data are available and have been scrutinised.

Charles Darwin University and Flinders University have established closer links and are routinely sharing information and ideas. At Flinders University, revisions to the pre-service primary courses have deliberately included more mathematics content knowledge because this was one area of concern. At Charles Darwin, the one-year postgraduate Diploma course is being phased out and the information gained from CEMENT will be used to develop new Units within the new course. In addition, the notion of "clinical acumen" that arose from the CEMENT conference is being deliberately used in discussions with PSTs, to develop their awareness of appropriate professional practice.

The University of New England is planning an internal professional development session in November. This was intended for earlier in 2012 but was put off due to time pressures. In addition, a session will be arranged with mathematicians and local teachers to consider some of the survey items and promote discussion around PCK.

The University of Queensland is exploring synergies and similarities between notions of clinical acumen and PCK with the aim of informing professional courses. This work is in its infancy but the processes of instrument development developed by the CEMENT project will be helpful.

The University of Melbourne is using some of the items as discussion starters in workshops with primary PSTs. The key person at this university took a new position at the start of 2012 which did affect the collection of data to some extent and the continuing influence of the project.

Wider Influences

Findings from the CEMENT project have been widely disseminated at mathematics education conferences and meetings. This dissemination has moved beyond presenting findings to providing stimulus for rich discussions about the outcomes of teacher education programs, mirroring the processes used during the project. This outcome is likely to be one of the more long-lasting legacies of the project. As a result a number of universities nationally and internationally have requested copies of the instruments to use in a variety of ways.

Internationally, Singapore and Chinese academics have indicated that they have interest in attempts to measure PCK. Copies of instruments have been provided to them and there is potential for future joint studies.

In Australia, apart from the seven participating universities, colleagues from several universities are using the items in diverse ways. In some places particular questions are being used as rich discussion starters in pre-service teacher education programs. In others, parts of the instruments developed are being used to inform assessment of students.

The approaches developed through the CEMENT project of item development and deep professional conversations around the nature of appropriate knowledge for PSTs are being emulated in a series of “roadshows” in regional Australia. The CEMENT team decided to target regional Australia because they acknowledged that education courses are important at these universities, but that often staff were isolated from mainstream discussions. It was not possible to organise these visits earlier because of the high teaching loads that many lecturers carry in regional areas; hence they have to be undertaken during non-contact time. Two members of the CEMENT team will be involved, one from the lead university and one from the relevant state. Using specific items as a discussion starter, they will lead groups of lecturers, local mathematics teachers and, if possible, mathematicians, in a discussion about the nature of teachers’ knowledge, specifically for teaching mathematics in schools. The process is similar to that used in round table discussions at the MERGA conference, and was also used with mathematics teachers at the Mathematical Association of Tasmania (MAT) conference. This replicates the discussions that the CEMENT team were involved with during the item writing and refinement process.

Information gained during the CEMENT project has also informed the Australian Council of Deans of Education (ACDE) report into entry level standards for pre-service teachers. The later data reported here will also be provided to the ACDE to provide additional information about the nature of mathematics courses for pre-service primary teachers.

A communiqué will be available from the final conference early in 2013. This will be disseminated to all teacher education providers in Australia.

There were challenges. In particular, the intended website was started but became caught up in changing university policies. In the meantime, the items and instruments, which were the key outcome from the project were being taken up by a number of universities. The survey is available on Qualtrics and can be used by any university on application to one of the project partners.

Recommendations

There are several recommendations that emerge from the CEMENT project. These are all predicated on the research evidence that PCK is a key determinant of teacher quality.

Student experiences

- Teacher preparation courses should intentionally focus on developing pedagogical content knowledge.

Anecdotal evidence about the nature of units and the intentions of mathematics educators suggests that PSTs are already taught through composite approaches in which the mathematics content is interwoven with pedagogical approaches. This recommendation suggests that these approaches should become clearer and more intentional, based on the research bases that are available about PCK.

- PSTs need to experience both mathematics and pedagogical approaches across all strands of the mathematics curriculum.

In mathematics education, some aspects of mathematics content are well researched, such as early number concepts, and ways in which understanding can be developed are understood. In other areas, despite a research base, the content tends to be somewhat neglected. Geometry is one example. All aspects of the mathematics content must be experienced by PSTs. Although the Australian Curriculum – Mathematics does not specify pedagogical approaches, the proficiencies, fluency, problem solving, reasoning and understanding, which interweave the curriculum imply that school students need to do more than practice activities. PSTs need pedagogical approaches that will support development of the proficiencies across all content areas of the mathematics curriculum.

Lecturer Quality

- Efforts should be made by Faculties and Schools of Education to recruit and develop continuing staff in mathematics education.

The findings from the lecturer survey suggest that opportunities to develop an understanding of LPCK are needed over a period of time, and that short term contract and casual tutors or lecturers may not have the LPCK appropriate to primary pre-service education. There is more research needed into the backgrounds and skills of university lecturers. A growing body of research seems to indicate that good teachers may not necessarily make the transition into tertiary teaching.

- Mathematics educators should engage in ongoing professional learning and appropriate induction programs.

The process of discussing the different items that was experienced throughout the CEMENT project has been shown to be an effective approach to thinking about mathematics education when used at conferences and other gatherings of mathematics educators at tertiary and school level. The process could also be used for induction of teachers into tertiary mathematics education, particularly those who enter on a casual or short term contract. This could also be the basis for a research study.

Initial Teacher Education Courses

- Universities should work to develop a common language to describe the components of initial teacher education courses.

The wide variation in terminology did hinder early communication in the CEMENT project. It was evident that every university had a unique approach to planning and providing for pre-service teachers. Although maintaining a diversity of types of initial teacher education is desirable, having ways in which these can be discussed and compared would aid benchmarking without changing the local nature of these courses.

- Benchmarking exercises should be established within and among universities to monitor the on-going development of mathematics education outcomes.

The instruments developed for the CEMENT project have considerable potential to be used for monitoring purposes. It would be possible, for example, to undertake a technical study to link the CEMENT outcomes with that from the TEDS-M study, gaining the benefits of an international comparison without the difficulty and expense of an international study. Internally, PSTs could be monitored within institutions using the CEMENT instruments to consider development at cohort level over time. It should be emphasised, however, that these instruments are not suitable for identifying an individual student's competence.

Conclusion

The CEMENT project has provided a unique opportunity to develop processes and instruments to provide a solid evidence base for improvement of mathematics education in initial teacher education courses. The project has made a lasting impact in the participating institutions and their networks. It has attracted interest nationally and internationally because of the innovative approach and the attempts to measure beyond mathematics content. The processes could be used in other areas of teacher education, such as literacy, and in other professional preparation courses, such as nursing. In addition, there is potential to develop induction practices for new tertiary educators. In short, it appears that this project has provided useful information that can impact on future practices in a variety of ways.

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Appendix A: Instruments – Primary Pre-service Teacher Survey

Section 1 contains the agreement between the University and the survey respondent.

This study is being conducted as part of the Office for Learning and Teaching (OLT) project (PP10- 1638) titled Building the Culture of Evidence-based Practice in Teacher Preparation for Mathematics Teaching. Details about the project were provided to you in the email that contained the link to this survey. Please read the statements below and then click on the appropriate button.

Clicking on 'I agree' implies consent to participate in this study.

1. I have read and understood the 'Information Sheet' for this project which was emailed to me.
2. The nature and possible effects of the study have been explained to me in the email information sheet.
3. I understand that the study involves completing this survey which will take no more than one hour.
4. I understand that participation involves no particular risk.
5. I understand that all research data will be securely stored on the University of Tasmania premises for at least five years, and will then be destroyed.
6. Any questions that I have asked have been answered to my satisfaction.
7. I agree that research data gathered from me for the study may be published provided that I cannot be identified as a participant.
8. I understand that the researchers will maintain my identity confidential and that any information I supply to the researcher(s) will be used only for the purposes of the research.
9. I agree to participate in this investigation and understand that I may withdraw at any time without any effect, and if I so wish, may request that any data I have supplied to date be withdrawn from the research.

Support for this activity has been provided by the Australian Learning and Teaching Council Ltd, an initiative of the Australian Government Department of Education, Employment and Workplace Relations. The views expressed in this activity do not necessarily reflect the views of the Australian Learning and Teaching Council.

☐ I Agree ☐ I Disagree

Section 2 of the survey asks for information on what institution the student is studying at, what courses, previous highest educational level attained, highest level of mathematics or statistics completed previous to the current degree, mode of study (internal/external; full-time/part-time), planned year of completion, country of previous education, Aboriginal/Torres Strait Islander status, and English language status.

Section 3 is a block of 10 BLF questions.

The following questions are about your general views of mathematics and mathematics learning and teaching. Please select the option that best describes your views.					
	Strongly Disagree	**Disagree**	**Neither Agree nor Disagree**	**Agree**	**Strongly Agree**
Mathematics is a beautiful and creative human endeavour.					
Periods of uncertainty and confusion are important for mathematics learning.					
Acknowledging multiple ways of mathematical thinking may confuse children.					
Mathematical ideas exist independently of human ability to discover them.					
Students learn by practicing procedures and methods for performing mathematical tasks.					
Teachers must be able to represent mathematical ideas in a variety of ways.					
The procedures and methods used in mathematics guarantee right answers.					
Justifying mathematical thinking is an important part of learning mathematics.					
The teacher must be receptive to the students' suggestions and ideas.					

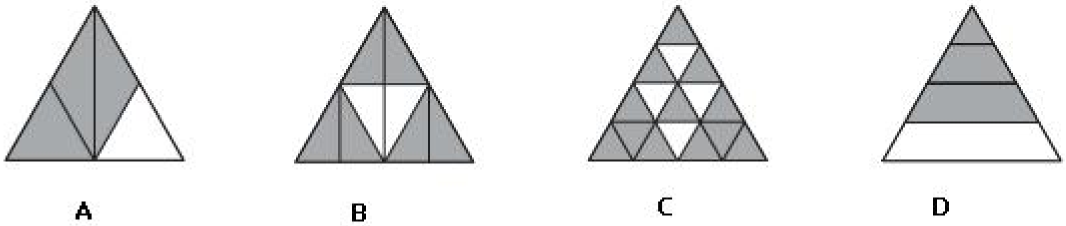
	Not at all confident	**A little confident**	**Don't know**	**Fairly confident**	**Completely confident**
Please rate your confidence to teach mathematics at the grade levels that you will be qualified to teach on the following scale.					

Section 4 is a block of 19 MCK questions that appear in random order. Not all questions are presented in every survey instance.

	Always True	Sometimes true	Never true
The product of an odd number and an even number is odd.			

	None	Ten	One hundred	Infinitely Many
How many different numbers are there between 0.7 and 0.8?				

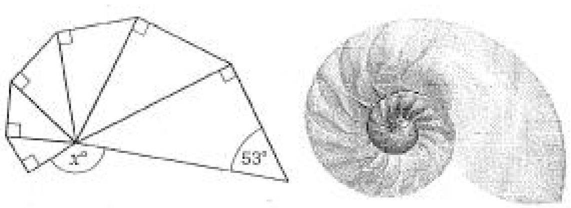
Which diagram does NOT have 3⁄4 of the area shaded?



	8.5%	25%	30%	42.5%
Twelve (12) chips are labelled 2, 3, 5, 6, 8, 10, 11, 12, 14, 15, 18 and 20 respectively. The twelve chips are placed in a bag and one is drawn out at random. What is the probability that the number on the chip is both even and a multiple of 3?				

	5.8m	6m	9m	10.8m
An upright 1-metre stick casts a shadow that is 60 centimetres long. At the same time, a flagpole casts a shadow that is 5.4 metres long. How high is the flagpole?				

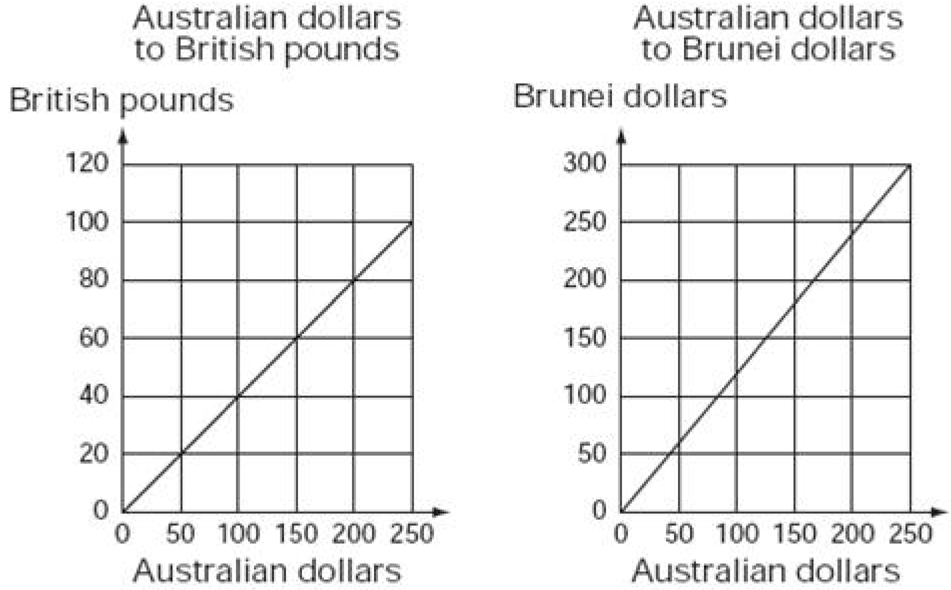
A model of how a shell grows can be made using enlarged copies of the same triangle. Here is a picture of a model. Here is a picture of a model.



	127	138	143	153	222
What is the value of x in degrees?					

	7	8	10	12
A set menu has a choice of 3 entrées, 2 mains and 2 desserts. A person chooses a meal that has one entrée, one main and one dessert. How many different meal combinations are possible?				

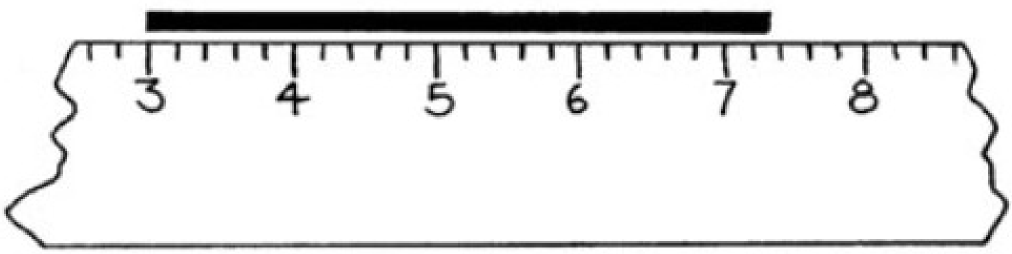
Below are two currency conversion graphs.



	20	50	125	150
How many Brunei dollars are equal in value to 50 British pounds?				

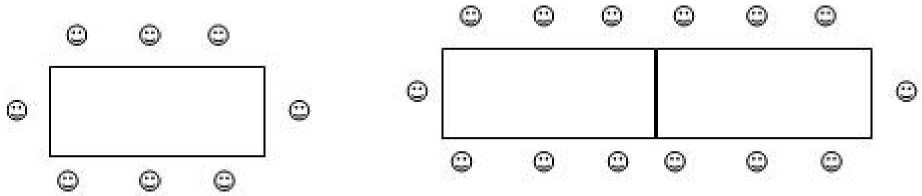
	12.5%	15%	17.5%	23.5%	25%
Steve buys a shirt that is discounted by 10% on the ticket. A sign on the rack stated, ‘Discount by a further 15%’. This is the same as a discount of what percentage of the original price of the shirt?					

A broken ruler, marked in centimetres, is being used to measure the length of a black bar as shown in the diagram below. What is the length of the black bar in centimetres? Be as accurate as possible. Type the number of centimetres in the box (do not include the units).



	$\frac{3}{6}, \frac{3}{5}, \frac{3}{4}$	$\frac{3}{4}, \frac{19}{24}, \frac{5}{6}$	$\frac{4}{5}, \frac{5}{6}, \frac{6}{7}$	$\frac{3}{4}, \frac{19}{24}, \frac{7}{8}$
Which one of the following contains a set of three fractions that are evenly spaced on a number line?				

A table can seat eight people: three on each side and one on each end. When tables are put together, more people can be seated (as shown here).



	t = 6 x p + 2	8 x p = t	p = 6 x t + 2	t = 7 x p + 1
Which of the following best describes the number of people (p) that can be seated at any number of tables (t)?				

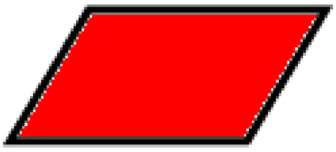
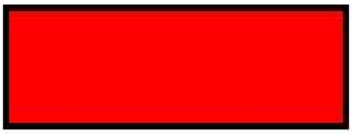
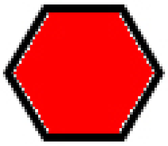
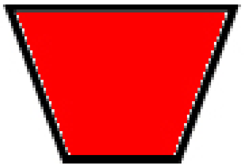
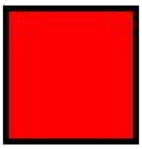
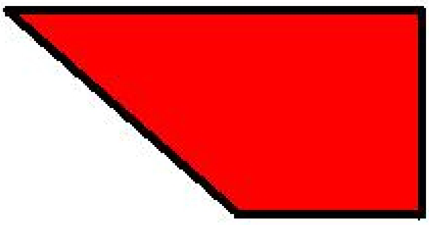
	307	316	370	614
Jane played 10 computer games. Her average score was 304. After her 11th game, her average was 310. What was Jane's score in her 11th game?				

Indicate whether each of the following statements is True or False.	**True**	**False**
A transformation is defined as a slide from one position to another without turning.		
Two shapes are congruent if they differ only in position and orientation in space.		
An enlargement with a scale factor of 2 doubles the area of a shape.		
If two shapes are similar then one is a scaled version of the other.		
An enlargement with a scale factor of 1 doubles the lengths of the sides of the shape.		

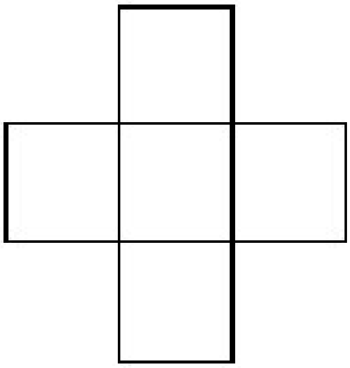
	5(x + 7) = 52	**5x + 7 = 52**	**7x + 5 = 52**	**7(x + 5) = 52**	**x = 52 x 5 + 7**
I think of a number, multiply it by 5 and add 7 to get an answer of 52. If my number was x, what equation represents this?					

Classify each of the following as **Never True**, **Sometimes True** or **Always True** where a and b are real numbers.

	Never True	**Sometimes True**	**Always True**
a x b = b x a			
a ÷ b = b ÷ a			
5 + a > a			
6 ÷ a > a			
$a^2 < a$			
$a^2 + b^2 = (a + b)^2$			
a – b = b - a			

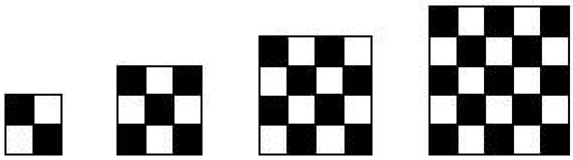
A parallelogram is a quadrilateral for which pairs of opposite sides are parallel. For each of the following shapes mark "True" if it is a parallelogram or "False" if it is not a parallelogram.	**True**	**False**
		
		
		
		
		
		
		

A target is made from 5 squares the same size, as shown.



	48	60	80	96	240
The perimeter of the cross is 48m. What area in square metres (m^2) is covered by the cross?					

A tiler drew some patterns of white and coloured tiles to fill a square space and put the information in a table.



Side length of square space (Tiles)	**Total number of white tiles**
2	2
3	4
4	8
5	12

	250	1200	1250	2500
How many white tiles would be needed for a square space with a side length of 50 tiles?				

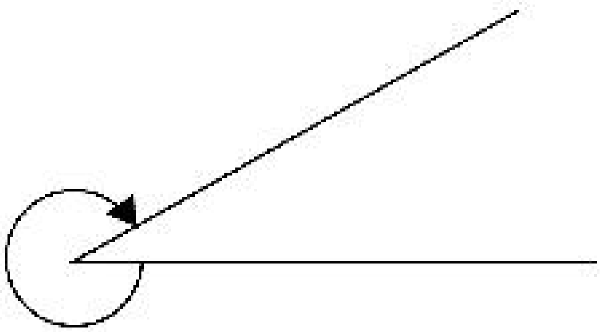
Section 5 is a block of 14 PCK questions that appear in random order. Not all questions are presented in every survey instance.

Students were asked to respond to the following question:
A box contains 18 red jubes, 10 green jubes, 10 yellow jubes and 2 black jubes. Without looking, Sheryl takes a jube from the box. What is the chance that the jube is green?

One student says that the chance is 1 in 4. To help interpret this response, which of the following is the most appropriate question to ask next?

☐ It's not clear what they think, so I'd ask them a similar question, but with only 8 red jubes instead of 18 red jubes.
☐ It's not clear what they think, so I'd ask them a similar question with smaller numbers such as: 10 red jubes, 5 green jubes, 4 yellow jubes and 1 black jube.
☐ It's not clear what they think, so I'd ask them a similar question with smaller numbers and fewer categories such as: 7 red jubes, 5 green jubes, and 3 yellow jubes.
☐ Since the student has responded correctly, it is not necessary to do anything more.

When asked to measure the angle below with a protractor, Kylie answers that it is 30°. She asks you if she is correct. For each of the following statements, indicate if you would definitely say it to Kylie, might say it to Kylie, or definitely not say it to Kylie.



	Definitely WOULD NOT say	Might Say	WOULD definitely say
Did you measure the amount of space between the lines?			
Well done, Kylie, you're absolutely correct.			
Make sure you line up the protractor correctly.			
Remember that angles are about the amount of turn, and the arrow shows the direction of turn.			
You need to subtract that from 360°.			
This one's tricky because your protractor will only measure angles up to 180°			
Can you show me which angle you are trying to measure?			

A 270 g packet of chocolate says "35% more chocolate for free". What is the best way to use this with an upper primary class to develop their mathematical understanding?

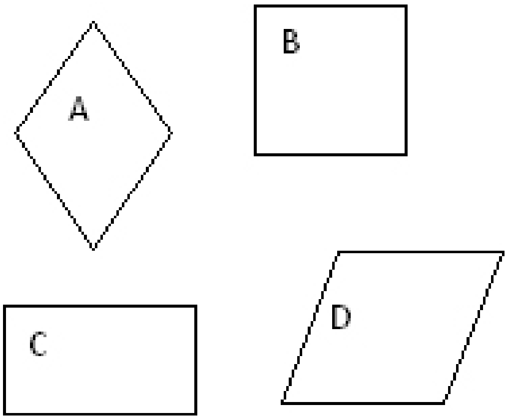
☐ As a starter for a research project about the use of maths in advertising.
☐ I could get students to calculate 35% of 270 g.
☐ As a starter to discuss percentage increase.
☐ I wouldn't use it – the numbers are too hard.

A Year 5 teacher asked her students to determine the value of the following calculation on their calculators:

2 + 3 x 4 =

The class was surprised to find that some student calculators gave a result of 14, while others gave a result of 20. Which of the following best matches your likely response to this situation?

☐ Use the difference as a motivation to teach the students how to use correct order of operations, highlighting an acronym such as BODMAS.
☐ Show the students how to use parentheses or brackets when entering expressions into their calculators.
☐ Check school booklists and supplies to make sure that only one kind of calculator was available to students in the class.
☐ Ask the students to explain the different results, and use their explanations to discuss the order of operations as an arbitrary convention.



Tommy is in Year 5. He states that A is the only rhombus because it's a diamond.
What might you do to help Tommy develop his understanding of shapes?

	WOULD NOT do	**Might do**	**WOULD definitely do**
Tell Tommy that only A and D are rhombuses			
Tell Tommy that D is also a rhombus as it looks like a square that has been rhommed by a bus.			
Ask Tommy to turn all the shapes into the same orientation as A.			
Ask Tommy to measure the sides of each shape.			
Tell Tommy that he's correct.			

Ann and Bob are Year 6 students completing a task in which they are asked to investigate the areas of rectangles with a perimeter of 24 cm. Ann claims that the maximum area is 36 cm2, while Bob claims that it is 35 cm2. Which of the following is the most likely explanation of why one of them is incorrect.

- ☐ Ask the student to measure again and be more careful.
- ☐ Tell the student that 7 popsticks is “close enough”.
- ☐ Show me how much of the popstick you would need to fill the missing part.
- ☐ Tell the student to use something smaller like unifix cubes to fill in the missing part.

Penny is a Year 4 student who is attempting to use a subtraction algorithm. In the following example of her work, something is incorrect.

What would you do to help Penny understand how to use this algorithm?

	WOULD NOT do	**Might do**	**WOULD definitely do**
Show her how to do the algorithm, then let Penny do another one.			
Get her to use the algorithm to calculate 709 - 84.			
Give her a calculator to check her answer.			
Get her to calculate 797 - 84.			
Use multibase arithmetic blocks (MAB) to demonstrate the process.			
Suggest using an empty number line.			

A teacher sets the following proportional reasoning task for an upper primary class:

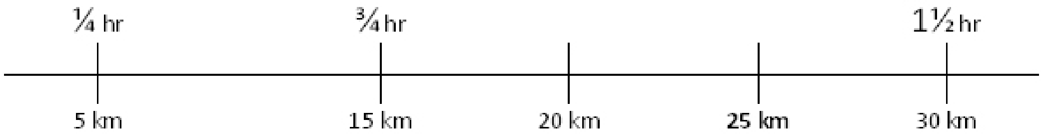
Bill and Ben were out on a Sunday morning bike ride. After three quarters of an hour they passed a sign that showed they had ridden 15 kilometres since they left home and that they still had 25 kilometres to reach their destination. How long will it take them to get there?

Which of the following representations is most helpful for the teacher to develop the students' understanding of proportional reasoning in solving this problem?

☐ Cross multiplying

Time (hr)	Distance (km)
¾	15
x	**25**

☐ Double number line



☐ Ratio table

Time	¾ hr	¼ hr	1 hr		
Distance	15 km	5 km		1 km	**25 km**

☐ Find the unit rate:
Riding 15 km in ¾ hr is equivalent to riding 1 km in ¾ ÷ 15 hr.

A class of Year 2 students is using popsticks to measure the width of a desk. A student measures the width to be more than 7 popsticks, but less than 8. He asks if he can break a popstick to fill the missing part. What would you do to continue the learning created through the use of this task?

☐ Ask the student to measure again and be more careful.
☐ Tell the student that 7 popsticks is "close enough".
☐ Show me how much of the popstick you would need to fill the missing part.
☐ Tell the student to use something smaller like unifix cubes to fill in the missing part.

Your class is exploring measurement concepts. Students make the following statements. Which one of these most urgently requires teacher intervention?

☐ Area is the space inside a shape.
☐ As the perimeter increases, the area always increases.
☐ Volume is the amount of space a shape takes up.
☐ Area is a measurement of the surface.

When asked to describe how they determined

$$\frac{2}{3} \div \frac{3}{4}$$

a student wrote the following on the classroom whiteboard:

$$\frac{2}{3} \div \frac{3}{4}$$

$$= \frac{8}{12} \div \frac{9}{12}$$

$$= 8 \div 9$$

$$= \frac{8}{9}$$

How would you respond to this?

☐ Remind them that it is only necessary to find a common denominator when doing addition and subtraction.

☐ Let them know that this method will work only sometimes and that to divide fractions they should instead invert the second fraction and then multiply.

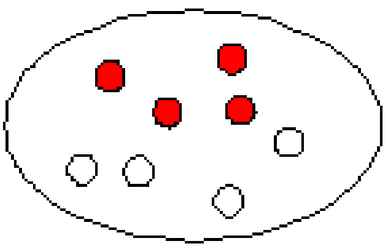
☐ Explain that the twelves can be cancelled out only when there is one on the numerator and one on the denominator.

☐ Reassure them that this procedure is acceptable, but ask them to explain their thinking to other students.

A student says that 1/4 + 1/4 is 2/8. She uses counters to show this as follows:

Given what the student has just shown you, which of the following representations of 1/4 + 1/4 is most likely to help her to see that 1/4 + 1/4 = 1/2?

☐



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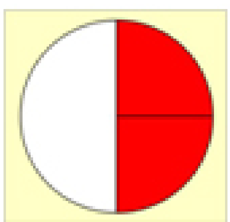

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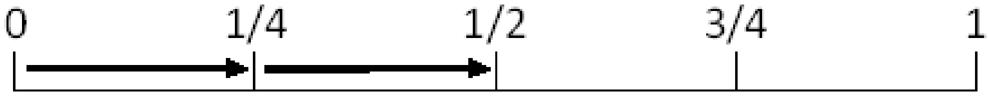

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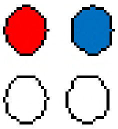

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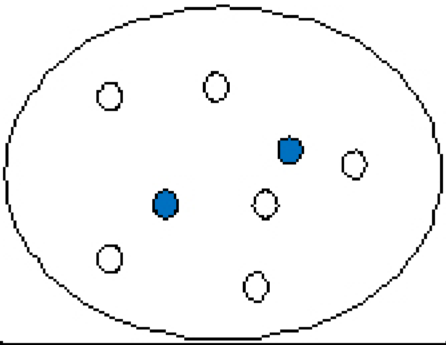
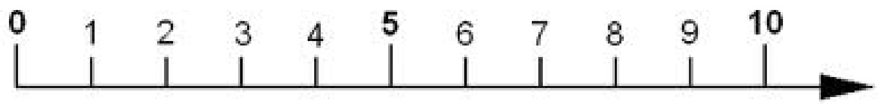
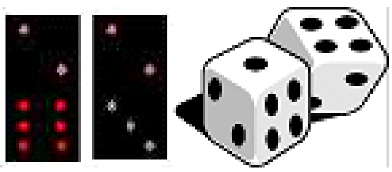


An important skill for young children to have is the ability to instantly see how many objects are in a small group, otherwise known as 'subitising'. Which of these is the most appropriate materials to use when helping students develop these skills?

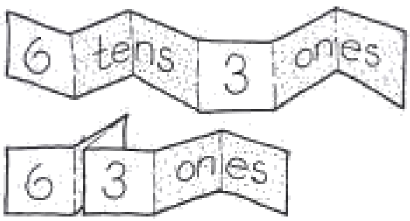
☐ A number line



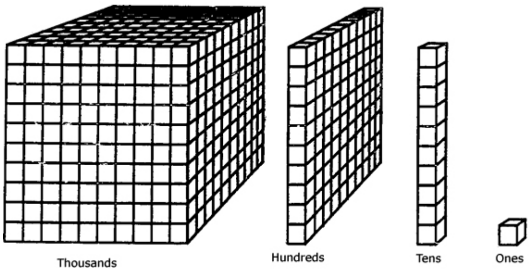
☐ Dominoes and dice



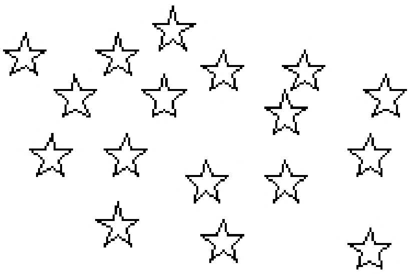
☐ Numeral Expander



☐ Multi Base Arithmetic Block (MAB or Dienes' Blocks)



☐ A large collection of similar objects



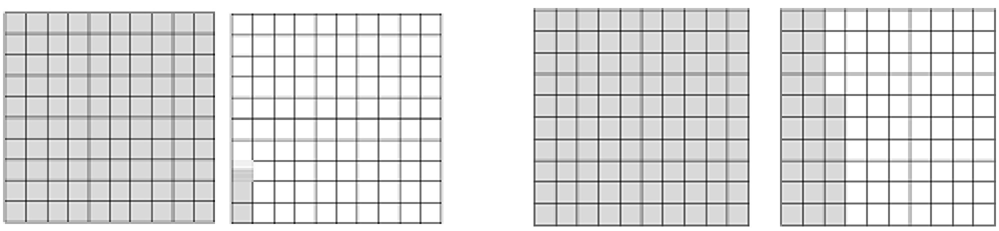
Which of the following explanations is least likely to be helpful in assisting a student who is struggling to understand that 1.26 is greater than 1.026?

☐ Multiplying both numbers by 1000 gives us 1260 and 1026.
1260 is greater than 1026 so 1.26 is greater than 1.026.

☐ 1.26 is 1 whole + 2 tenths + 6 hundredths
1.026 is 1 whole + 0 tenths + 2 hundredths + 6 thousandths

☐ It's easier to compare decimals that are the same length and we can add zeros to the end of a decimal without changing it, so, 1.26 is the same as 1.260. We can now see that 1.26 is greater than 1.026 because 260 is greater than 026 (which is 26).

☐



1.026 1.26

Section 6 of the survey asks participants whether they are willing to be interviewed, provides an opportunity for participants to go back over questions, and to provide their details if they would like an entry to win an iPod Touch.

Appendix B: Instruments – Secondary Pre-service Teacher Survey

Section 1 contains the agreement between the University and the survey respondent.

This study is being conducted as part of the Office for Learning and Teaching (OLT) project (PP10- 1638) titled Building the Culture of Evidence-based Practice in Teacher Preparation for Mathematics Teaching. Details about the project were provided to you in the email that contained the link to this survey. Please read the statements below and then click on the appropriate button.

Clicking on 'I agree' implies consent to participate in this study.

1. I have read and understood the 'Information Sheet' for this project which was emailed to me.
2. The nature and possible effects of the study have been explained to me in the email information sheet.
3. I understand that the study involves completing this survey which will take no more than one hour.
4. I understand that participation involves no particular risk.
5. I understand that all research data will be securely stored on the University of Tasmania premises for at least five years, and will then be destroyed.
6. Any questions that I have asked have been answered to my satisfaction.
7. I agree that research data gathered from me for the study may be published provided that I cannot be identified as a participant.
8. I understand that the researchers will maintain my identity confidential and that any information I supply to the researcher(s) will be used only for the purposes of the research.
9. I agree to participate in this investigation and understand that I may withdraw at any time without any effect, and if I so wish, may request that any data I have supplied to date be withdrawn from the research.

Support for this activity has been provided by the Australian Learning and Teaching Council Ltd, an initiative of the Australian Government Department of Education, Employment and Workplace Relations. The views expressed in this activity do not necessarily reflect the views of the Australian Learning and Teaching Council.

☐ I Agree ☐ I Disagree

Section 2 of the survey asks for information to create coding that provided an ability to match the data from this survey with data from a proceeding survey.

Section 3 of the survey asks for information on what institution the student is studying at, what courses, previous highest educational level attained, highest level of mathematics or statistics completed previous to the current degree, mode of study (internal/external; full-time/part-time), planned year of completion, country of previous education, Aboriginal/Torres Strait Islander status, and English language status.

Section 4 is a block of 10 BLF questions.

The following questions are about your general views of mathematics and mathematics learning and teaching. Please select the option that best describes your views.					
	Strongly Disagree	**Disagree**	**Neither Agree nor Disagree**	**Agree**	**Strongly Agree**
Mathematics is a beautiful and creative human endeavour.					
Periods of uncertainty and confusion are important for mathematics learning.					
Acknowledging multiple ways of mathematical thinking may confuse children.					
Mathematical ideas exist independently of human ability to discover them.					
Students learn by practicing procedures and methods for performing mathematical tasks.					
Teachers must be able to represent mathematical ideas in a variety of ways.					
The procedures and methods used in mathematics guarantee right answers.					
Justifying mathematical thinking is an important part of learning mathematics.					
The teacher must be receptive to the students' suggestions and ideas.					

	Not at all confident	**A little confident**	**Don't know**	**Fairly confident**	**Completely confident**
Please rate your confidence to teach mathematics at the grade levels that you will be qualified to teach on the following scale.					

Section 5 is a block of 17 MCK questions that appear in random order. Not all questions are presented in every survey instance.

A student picks a value for *x*, and uses it in the function f(*x*) = $2x^2$ to get an answer. He then picks a new value for *x*, which is 3 times his original choice. His new answer is:
☐ 3 times his old one ☐ 6 times his old one ☐ 9 times his old one ☐ 18 times his old one ☐ 36 times his old one ☐ Can't tell how the new answer relates to the old one

A student has attempted to solve $(x + 4)^2 = 49 - x^2$. The student's solution is reproduced below.

$$1.\quad (x+4)^2 = 49 - x^2$$

$$2.\quad x^2 + 16 = 49 - x^2$$

$$3.\quad 2x^2 = 33$$

$$4.\quad x^2 = \frac{33}{2}$$

$$5.\quad x = \frac{\sqrt{33}}{\sqrt{2}}$$

$$6.\quad x = \frac{\sqrt{66}}{2}$$

Look at each line of the student's solution. Indicate whether each line is equivalent to the line above it.

☐ Line 2 is equivalent to Line 1
☐ Line 3 is equivalent to Line 2
☐ Line 4 is equivalent to Line 3
☐ Line 5 is equivalent to Line 4
☐ Line 6 is equivalent to Line 5

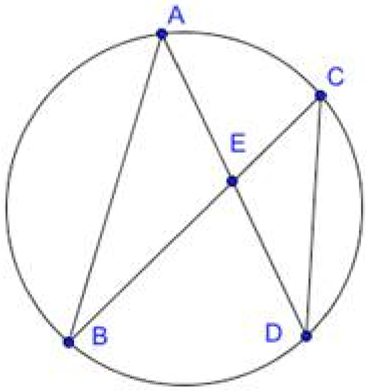
A tortoise has been fitted with a GPS tracking device that reports that its speed is 0.87 km/h. The tortoise has been travelling at this steady speed for 350 m. Which of the following calculations (if any) would allow you to find out how long, in minutes, it has taken the tortoise to travel this distance?

	Yes	**No**
0.87 x 350 x 60		
0.87 x 0.35 x 60		
0.87 ÷ 0.35 x 60		
0.35 ÷ 0.87 x 60		
350 ÷ 0.87 x (60 / 1000)		
0.87 ÷ 350 x (60 / 1000)		

In a lottery in which 6 numbered balls are drawn from a collection numbered from 1 to 30, the probability of drawing the numbers 2, 11, 15, 16, 23, and 30 is:

☐ Less likely than drawing the numbers 1, 2, 3, 4, 5, and 6.
☐ The same as the probability of drawing the numbers 1, 2, 3, 4, 5, and 6.
☐ More likely than drawing the numbers 1, 2, 3, 4, 5, and 6.
☐ We would need to conduct a trial to be sure.

The diagram below is not drawn to scale. Angle ABE measures 30o and angle CED measures 110°.



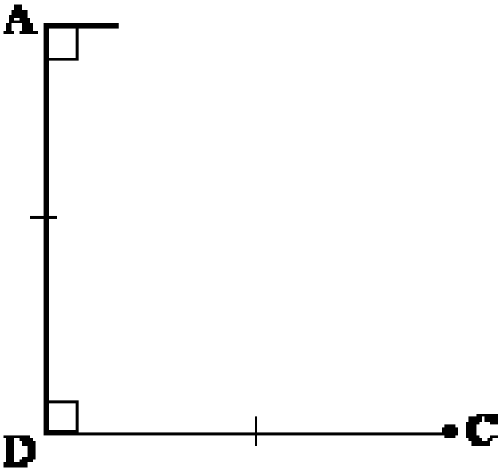
What additional information is necessary in order to find the size of angle ECD?

☐ Whether or not AB and CD are parallel.
☐ Whether or not triangle CED is isosceles.
☐ Whether or not E is the centre of the circle.
☐ No additional information is needed.

When analysing her 50 scores for a video game, Jenni noticed that the mean score was substantially larger than the median score. What is the most likely reason for this to occur?

☐ Her scores have been gradually improving.
☐ There is an outlier score, much larger than most other scores.
☐ The mean of positive scores like these is usually larger than the median.
☐ The distribution of the scores is bi-modal.

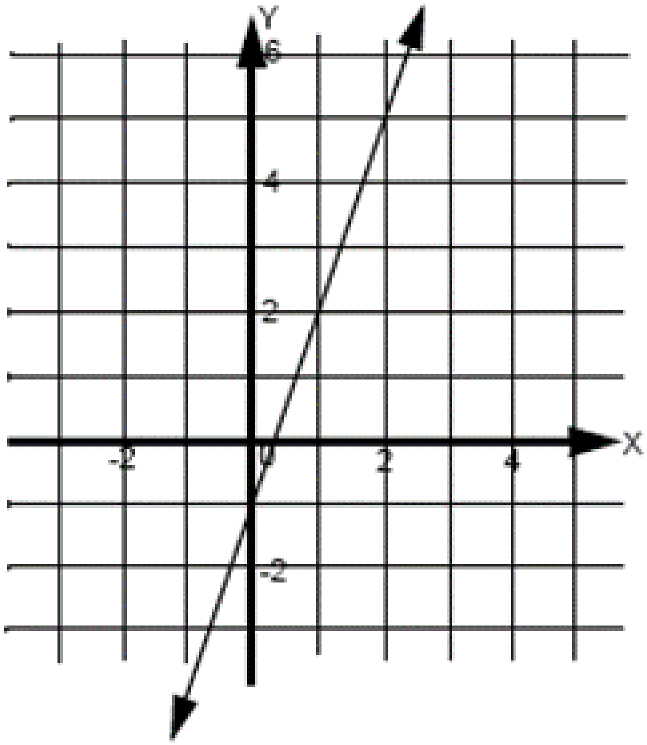
A partial drawing of a quadrilateral is shown in the diagram below. If no other sides or angles are congruent to the ones shown, which of the following best describes the figure?



☐ square
☐ rectangle
☐ parallelogram
☐ trapezium

	5.8m	**6m**	**9m**	**10.8m**
An upright 1-metre stick casts a shadow that is 60 centimetres long. At the same time, a flagpole casts a shadow that is 5.4 metres long. How high is the flagpole?				

Two 6-sided dice are rolled, and the difference between the two numbers is calculated. If the numbers shown are not the same, the difference between the two numbers is found by subtracting the smaller number from the larger number. If the rolled dice show identical numbers, the difference between the two numbers will be zero. Which of the following is the most likely difference?
☐ 0 ☐ 1 ☐ 2 ☐ 3
Here is the graph of a linear function.



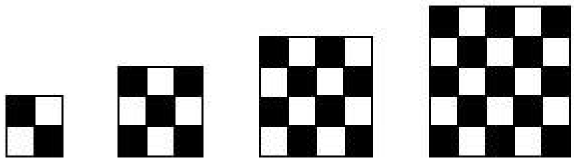
Which **one** of these points will lie on it?

☐ (-7, -5)
☐ (-5, -14)
☐ (6. 17)
☐ (8, 3)

A signal at a pedestrian crossing near Sam's house has the following cycle. It stays red for 30 seconds. It then changes to green for 20 seconds. What is the probability, to 2 decimal places, that it will be **green** the next time Sam wants to use this crossing?
☐ 0.00 ☐ 0.20 ☐ 0.40 ☐ 0.50 ☐ 0.67

For each statement shown below, indicate whether it is True or False.	**True**	**False**
$\sqrt{a}+\sqrt{b}=\sqrt{a+b}$		
$\sqrt{a}-\sqrt{b}=\sqrt{a-b}$		
$\sqrt{a}\times\sqrt{b}=\sqrt{a\times b}$		
$\sqrt{a}\div\sqrt{b}=\sqrt{a\div b}$		

A tiler drew some patterns of white and coloured tiles to fill a square space and put the information in a table.



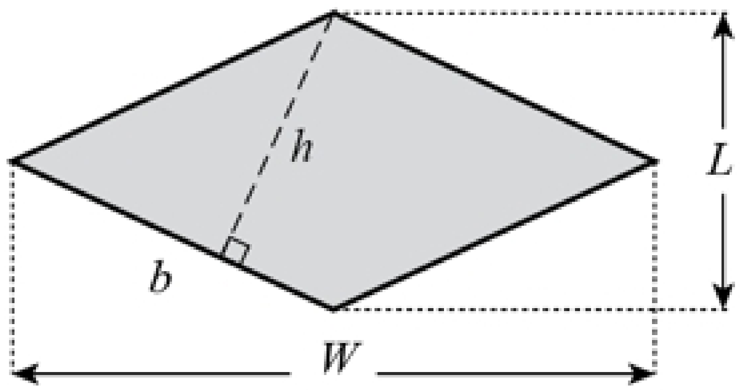
Side length of square space (Tiles)	Total number of white tiles
2	2
3	4
4	8
5	12

	250	1200	1250	2500
How many white tiles would be needed for a square space with a side length of 50 tiles?				

In the following equations and inequalities, *a* and *b* are real numbers. Classify each as **Never True**, **Sometimes True** or **Always True**.

	Never True	Sometimes True	Always True
$a \times b = b \times a$			
$a \div b = b \div a$			
$5 + a > a$			
$6 \div a > a$			
$a^2 < a$			
$a^2 + b^2 = (a + b)^2$			
$a - b = b - a$			

This diagram shows four measurements of a rhombus of side length b.



☐ 2hb = LW
☐ 2hW = Lb
☐ hb = 2LW
☐ hW = 2Lb

A die has faces numbered 1 to 6. The die is biased so that the number 6 will appear more often than each of the other numbers. The numbers 1 to 5 are equally likely to occur. The die was rolled 1200 times and it was noted that the 6 appeared 450 times. Which statement is correct?

- ☐ The probability of rolling the number 5 is about one seventh.
- ☐ The number 6 is about twice as likely to occur as any other number.
- ☐ The number 6 is about three times as likely to occur as any other number.
- ☐ The probability of rolling an even number is about equal to the probability of rolling an odd number.

Claire thinks of a number, n
She multiplies the number by itself.
She then halves that answer and subtracts 10.
Which expression shows what Claire did?

☐

$$\frac{2n-10}{2}$$

☐

$$\frac{2n}{2}-10$$

☐

$$\frac{n^2}{2}-10$$

☐

$$\frac{n^2-10}{2}$$

Section 6 is a block of 15 PCK questions that appear in random order. Not all questions are presented in every survey instance.

The following question was given to Year 8 students:

Some children are making batches of cordial by mixing together sweet concentrate and water.

Sally uses 4 cups of sweet concentrate and 13 cups of water.

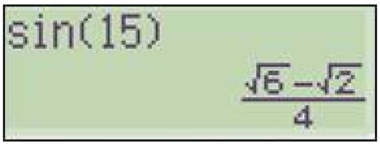
Myles uses 6 cups of sweet concentrate and 15 cups of water.

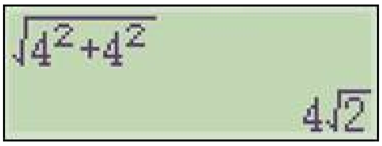
One student has a misconception and thinks these cordial mixes will have the same sweetness.

Which of the following cordial mixes might this student ALSO think will have the same sweetness?

- ☐ Aisha uses 8 cups of sweet cordial mix and 26 cups of water.
- ☐ Carly uses 10 cups of sweet cordial mix and 19 cups of water.
- ☐ Deng uses 8 cups of sweet cordial mix and 20 cups of water.
- ☐ Erin uses 10 cups of sweet cordial mix and 28 cups of water.

A new calculator routinely provided some answers using exact arithmetic, such as:

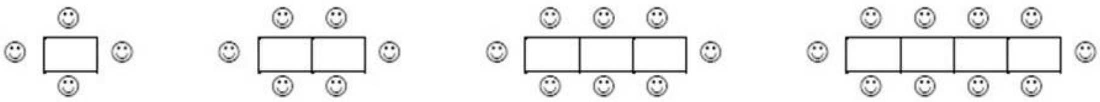




Which of the following statements best describes the suitability of such a calculator for use in a secondary school?

☐ Unsuitable, as the answers shown are wrong.
☐ Unsuitable, as it is not yet approved by examination authorities.
☐ Unsuitable, as decimal answers are more helpful for practical calculations.
☐ Suitable, as it will provoke discussions about exact and approximate numbers.
☐ Suitable, as it will reduce demands on student algebraic and numerical skills.

This diagram represents the number of people that can be seated as small tables are added.



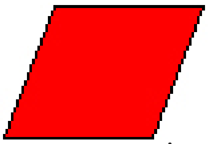
Students were asked to find a rule to link the number of tables used and the number of people who could be seated, and express this algebraically using T for the number of tables and P for the number of people.

Three students' answers were: **P = 2T + 2** ***P = (T – 2) x 2 + 6*** **P = 2(T + 1)**

What representation could you best use to convince them that these solutions are the same?

☐ Work through the algebra on the board.
☐ Create a table of values for each rule and compare them.
☐ Draw a graph for each rule on the same axes.
☐ Get them to try a different problem with the same relationship.

A Year 8 student wrote "This shape is a pushed over square".



Which of the following would be the most appropriate feedback to give to students to develop their geometrical thinking?

☐ We call that shape a rhombus. Write the name in your book.
☐ That's a great description. I like that you wrote a complete sentence.
☐ What if you turned it around so the point was downwards? Would it still be a pushed over square?
☐ Explain to me why it is like a square.

A class was asked to calculate:

$$\frac{2}{3} \div \frac{3}{4}$$

Jessica wrote the following on the whiteboard:

$$\frac{2}{3} \div \frac{3}{4}$$

$$= \frac{8}{12} \div \frac{9}{12}$$

$$= 8 \div 9$$

$$= \frac{8}{9}$$

Of the following responses, which is the most appropriate?

☐ Remind Jessica that it is only necessary to find a common denominator when doing addition and subtraction.

☐ Let Jessica know that this method will work only sometimes and that to divide fractions she should instead invert the second fraction and then multiply.

☐ Explain that the twelves can be cancelled out only when there is one on the numerator and one on the denominator.

☐ Reassure Jessica that this procedure is acceptable, but ask Jessica to explain her thinking to other students.

A teacher implemented the following activity from a lower secondary mathematics textbook to help students understand the formula for the circumference of a circle. Students worked in small groups to measure the diameters and circumferences of a set of circular objects. They used string to measure the circumferences and a ruler to measure the diameters. The class recorded their results on the whiteboard in the table below.

Object	**Circumference (*C*)**	**Diameter (*d*)**	***c/d***
Can of soup	23.2 cm	7.5 cm	3.09
Egg ring	24.3 cm	7.5 cm	3.24
Biscuit cutter	18.7 cm	6.0 cm	3.12
Egg cup	14.4 cm	4.4 cm	3.27
Pie dish	40.2 cm	12.6 cm	3.19

One student then remarked that the C/d ratios were all different. What explanation or further activity should the teacher provide to ensure that students understand the purpose of this task?

☐ Engage the class in a discussion of measurement errors and ask them to measure some more circular objects and this time calculate the c/d ratios for them.

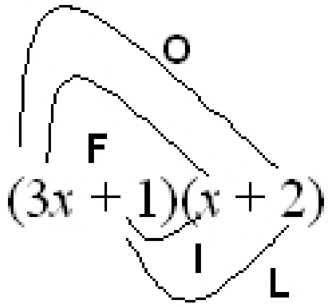
☐ Explain the ratios are so similar that we can assume a pattern of C/d = some constant, which we call “pi”. Tell students that the accepted value of pi is about 3.14, and their measurements and calculations were close to this value.

☐ Point out that the results suggest a pattern that we could investigate further by drawing a graph of circumference versus diameter.

☐ Provide the formula C = π x d and demonstrate how it can be used to calculate the circumference of a circle if we know the diameter.

The expansion of (3x + 1)(x + 2) relies on use of the distributive law.
Which of the following representations of (3x + 1)(x + 2) best illustrates how the distributive law is used in this expansion?

☐ FOIL (First, Outside, Inside, Last)



☐ Show the expansion as a long multiplication

	$3x$	$+1$
	x	$+2$
	$6x$	$+2$
$3x^2$	$+x$	
$3x^2$	$+7x$	$+2$

☐ Substitute numbers to show that the expansion is correct.

(3x + 1) (x + 2) = (3 ×7 + 1) (7 + 2) = 22 × 9 = 198
$3(x^2) + 7x + 2 = 3(7^2) + 7(7) + 2 = 147 + 49 + 2 = 198$

☐ Use an area diagram:

	x	x	x	1
x	x^2	x^2	x^2	x
2	$2x$	$2x$	$2x$	2

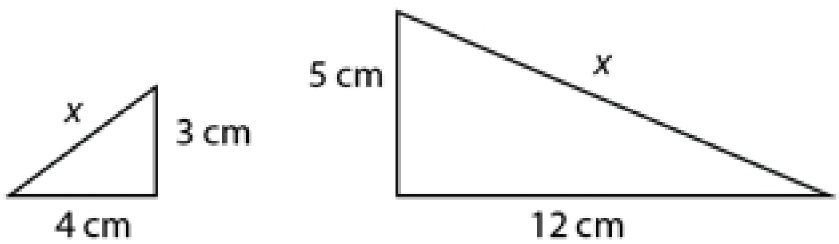
A teacher wants to highlight the role of the slope parameter, m, in the equation $y = mx + c$ and its effect on the slope of the graph of the straight line. She decides to do this by using a graphing calculator to plot a sequence of linear functions, but she needs to choose a good set of functions.

For each of the following sets of functions indicate if you think it is a good choice of sequence, a poor choice of sequence, or somewhere in between. The sequence of functions (to be used in the given order) are shown below.

	Poor choice	**Tolerable choice**	**Good choice**
$y = 3x - 2$, $y = 7x + 2$, $y - -3x + 4$, $y = 5x - 1$, $y = 1/5x + 4$			
$y = x - 2$, $y = 7x - 2$, $y = 1/4x - 2$, $y = -2x - 2$, $y = -1/5x - 2$			
$y = 3x + 1$, $y = 2x + 1$, $y = 1/4x + 1$, $y = 1/5x + 1$, $y = 10x + 1$			
$y = x - 1$, $y = -x - 1$, $y = 3x - 1$, $y = -3x - 1$, $y = 1/3x - 1$, $y = -1/3x - 1$			

In introducing Pythagoras' Theorem to a Year 9 class a preservice teacher conducted the following sequence of activities:

1. Asked students to draw squares on the sides of several right-angled triangles and explore the relationship between the square of the sides.
2. Gave the rule $a^2 + b^2 = c^2$ and asked students to memorise it.
3. Showed students how to calculate the hypotenuse of a right-angled triangle given the other two sides, using the following two examples:



4. Gave students several questions in which they were asked to find the length of the hypotenuse of a right-angled triangle.

When providing feedback on the lesson the mentor teacher made the following comments. With which of them do you agree?

	Agree	**Disagree**
Drawing squares on the sides of right-angled triangles wastes time as students will never be asked to prove Pythagoras' Theorem.		
Memorising the rule a2 + b2 = c2 is really important. Well done!		
Your examples both worked out to be whole numbers. It is important to also give examples that yield irrational answers.		
Just using questions where students have to find the hypotenuse is good as students would become confused if they were also asked questions where they had to find a short side.		

Below is a student's incorrect attempt to solve a pair of simultaneous equations:

$$3x - y = 7 \quad (1)$$
$$x + y = 9 \quad (2)$$
$$2x = -2$$
$$x = -1$$

Substitute into (2):

$$-1 + y = 9$$
$$y = 10$$

The student checks her solution via substitution into equation (1) and is surprised to see that it is does not make the equation true.
Which of the following statements gives the most likely explanation for the student's error and the most appropriate next step for the teacher to take?

☐ The student has tried to subtract equation (2) from equation (1) but "cancelled" the –y and +y to eliminate this variable. The teacher should tell the student to add the equations instead.
☐ The student has tried to subtract equation (2) from equation (1) but "cancelled" the –y and +y to eliminate this variable. The teacher should ask the student to explain why she chose to subtract rather than add these equations.
☐ The student has tried to subtract equation (2) from equation (1) but "cancelled" the –y and +y to eliminate this variable. The teacher should suggest that the student use the substitution method instead, by finding an expression for x or y from equation (2) and substituting this into equation (1).
☐ The student has incorrectly added equations (1) and (2). The teacher should ask the student to repeat this addition, ensuring she does it correctly.

This is a student's response to a test question:

5.
The following information is from a survey about smoking and lung disease among 250 people.

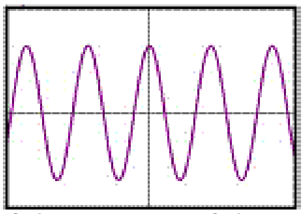
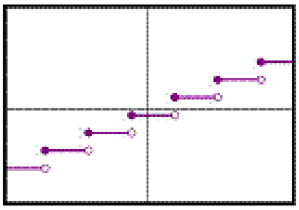
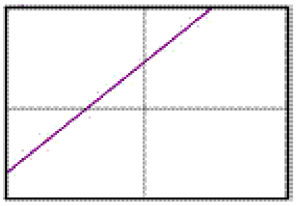
	Lung disease	No lung disease	Total
Smoking	90	60	150
No smoking	60	40	100
Total	150	100	250

Using this information, do you think that for this sample of people lung disease was caused by smoking? Explain your answer.

yes because 90 people died of lung canser who smok and only 60 of people who don't smoke

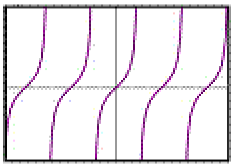
Indicate which of the following statements is a reasonable inference concerning this student's thinking.
☐ The student has considered only one column in the data table.
☐ The student has considered only one row in the data table.
☐ The student has been influenced by prior knowledge of issues concerning smoking and lung disease.
☐ The student may need further assistance to develop proportional reasoning.

The following is a part of a set of cards for students to sort:

If the purpose of the cards is to help students to understand the definition of 'function', which of the following would be the most useful addition to the set?

☐



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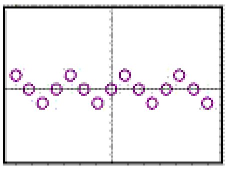

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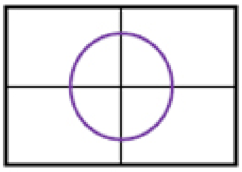

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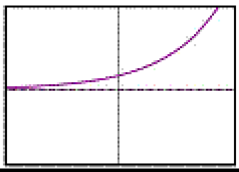


Students were asked to respond to the following question:
A box contains 18 red jubes, 10 green jubes, 10 yellow jubes and 2 black jubes. Without looking, Sheryl takes a jube from the box. What is the chance that the jube is green?

One student says that the chance is 1 in 4. To help interpret this response, which of the following is the most appropriate question to ask next?

☐ It's not clear what they think, so I'd ask them a similar question, but with only 8 red jubes instead of 18 red jubes.
☐ It's not clear what they think, so I'd ask them a similar question with smaller numbers such as: 10 red jubes, 5 green jubes, 4 yellow jubes and 1 black jube.
☐ It's not clear what they think, so I'd ask them a similar question with smaller numbers and fewer categories such as: 7 red jubes, 5 green jubes, and 3 yellow jubes.
☐ Since the student has responded correctly, it is not necessary to do anything more.

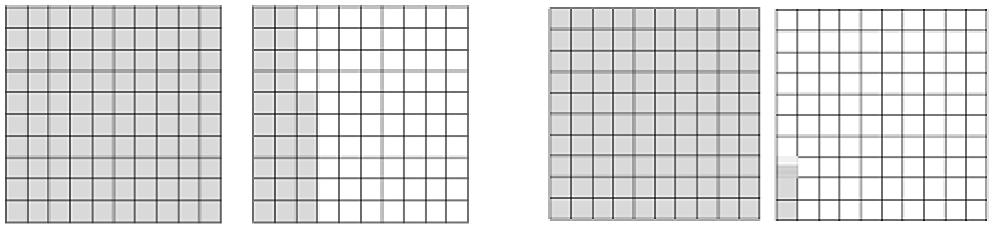
Which of the following explanations is least likely to be helpful in assisting a student who is struggling to understand that 1.26 is greater than 1.026?

☐ Multiplying both numbers by 1000 gives us 1260 and 1026.
1260 is greater than 1026 so 1.26 is greater than 1.026.

☐ 1.26 is 1 whole + 2 tenths + 6 hundredths
1.026 is 1 whole + 0 tenths + 2 hundredths + 6 thousandths

☐ It's easier to compare decimals that are the same length and we can add zeros to the end of a decimal without changing it, so, 1.26 is the same as 1.260. We can now see that 1.26 is greater than 1.026 because 260 is greater than 026 (which is 26).

☐



1.26 1.026

You are about to begin investigating index laws with a Year 7/8 class.
Choose the best approach for teaching the following:

$\mathbf{a^m \times a^n = a^{m+n}}$

$\mathbf{a^m \div a^n = a^{m-n}}$

$\mathbf{(a^m)^n = a^{mn}}$

☐ Provide the rules, demonstrate 3 examples, and ask the students to complete some exercises.

☐ Write the rules, begin with numerals, such as Base 10, then move to algebraic problems.

☐ Provide examples where the students search for patterns and develop each of the rules.

☐ Ask the students to work at their own pace through the text-book exercises. Students seek help when necessary.

Section 7 of the survey asks participants whether they are willing to be interviewed, provides an opportunity for participants to go back over questions, and to provide their details if they would like an entry to win an iPod Touch.

Appendix C: Final Evaluation September 2012

The Office for Learning and Teaching

Culture of Evidence-based Mathematics Education for New Teachers (CEMENT)

Of the Final Report: Building the culture of evidence-based practice in teacher preparation for mathematics teaching

Project Reference: PP10-1638

Final Report

September 2012

Associate Professor Debra Panizzon
(Monash University)

Project Outline

The aim of the OLT funded CEMENT (**C**ulture of **E**vidence-based **M**athematics **E**ducation for **N**ew **T**eachers) project was to provide the tools to promote a national culture of evidence-based practice in the preparation of teachers of mathematics. It involved participating universities in every state and territory with a view to:

- Developing instruments to measure the outcomes of teacher education programs in mathematics in terms of mathematical understanding, appropriate pedagogical knowledge, and attitudes and beliefs about mathematics.
- Generating approaches to support lecturers in making changes to their mathematics teaching practice informed by the collected data.
- Supplying data-driven evidence about effective models of teacher education in mathematics on which course changes might be structured.
- Disseminating findings to engage the teacher education, mathematics and statistics communities in a culture of evidence-based course development for pre-service teachers.

Lead institution: University of Tasmania (Associate Professors Rosemary Callingham and Kim Beswick).

Partner institutions: Charles Darwin University (Stephen Thornton), Flinders University (Dr Julie Clarke), Murdoch University (Barry Kissane), University of Melbourne (Associate Professor Helen Chick, relocated to University of Tasmania during the project), University of New England (Dr Pep Serow), University of Queensland (Professor Merrilyn Goos).

Purpose and Scope of the Evaluation

The aim of the evaluation was two fold:

- provide initial feedback to the Steering Committee to enhance the project in the short-term (see Appendix 1 Interim report); and
- review the processes, outcomes, significance, and sustainability of the completed project after completion in terms of its impact on pre-service mathematics teacher education.

The four overarching questions guiding the evaluation included:

1. What processes were planned and what were actually put in place for the project? Why the variation?
2. What were the observable short-term outcomes/outputs? To what extent were these intended outcomes/outputs achieved? Were there unintended outcomes/outputs?
3. What is the significance of the project in terms of mathematics pre-service teacher education? What are the longer-term benefits of the outputs of the project?
4. What measures promoted sustainability and dissemination of the project's focus and outcomes? Within participating institutions? Other teacher education institutions? Other stakeholders? How effective were these measures?

Data Methods and Analytical Strategy

In order to collect the evidence necessary to address these questions a range of data were collected (see Evaluation Plan Appendix 2) including:

- documentation (i.e., progress reports for OLT; other reports, minutes of meetings or briefing papers distributed to the Steering Committee via email list);
- attendance at key meetings of the Steering committee (i.e., end of March in Brisbane 2011);
- access to the data and findings from student surveys and interviews with teacher educators reported in papers;
- interviews conducted by the evaluator with Rosemary Callingham (in the role of project leader) to monitor project progress along with an overview of the data and how this might be used by participating universities to improve mathematics education for teacher education students; and
- written insights from the project participants about their overall perceptions of the immediate and longer-term impact of the CEMENT project.

The various documents, interview extracts, and written responses developed were analysed using the four key evaluation questions as a framework for identifying appropriate evidence. Triangulation of data from these sources ensured that results presented in this report are not based upon the insights of one individual but representative of the project team as a collective.

Processes Driving the Project

Reflecting upon the project, it is possible to identify a number of processes that ensured its successful progress and completion.

1. A management structure that was clear with open lines of communication. For example, the establishment of the Steering Committee (including each of the project participants) and appointment of a Project Officer was completed within a short time of project commencement. With roles clearly defined, the email list used by the Project Officer ensured ongoing communication among the Steering Committee, other stakeholders, and the evaluator.
2. Face-to-face meetings that included the whole team at specified times or opportunistically (e.g., if the group were attending a conference). While these meetings did not occur frequently, they often led to substantive additions to the project. For example, at the second meeting of the team in March 2011 a number of issues were raised by the project team in their discussions around the importance of knowing the educational qualifications of mathematics teacher educators. The result of this rigorous discussion was the development and implementation of an additional survey to collect these data that added to the findings of the project. This was expressed clearly by one of the Steering Committee:

   > *Face to face whole team meetings were vital. There were only a few of these, but from them emerged key insights into the questions we were investigating and other issues that we hadn't initially considered, such as (a) the amazing diversity of pre-service program characteristics and (b) the knowledge that we, as teacher educators, bring to bear on designing courses/subjects/units and learning and assessment tasks for our students.*

3. The inclusion of personnel (i.e., mathematics educators) from a range of instritutions that ensured representatation of the Australian higher education sector (e.g., Charles Darwin and

UNE along with city universities). This step created greater 'buy in' from other mathematics educators outside of the key universities who were keen to participate in the data collection thereby broadening the scope of CEMENT from the outset.

4. The establishment of mechanisms to ensure that each of the Steering Committee was involved in the development, trialing, and collection of data using online platforms that facilitated the sharing and exchanging of information.
5. The identifification of key conferences in mathematics and general education for the dissemination of findings from the project, which seemed to provide a focal point for the project team and helped meeting project milestones.

In terms of the original application, most of these processes were identified as part of the project implementation. However, the degree of collaboration between members of the project team, key institutions involved in the CEMENT project and colleagues from other institutions was stronger than anticipated initially. As articulated by one of the Steering Committee:

> *The collaborations between partners were a key to the project; these were built in, but seemed to me to be even more successful than expected. From my perspective, increased collaboration between staff at my university was less expected, but emerged as an important factor. CEMENT provided a vehicle for discussing our work amongst ourselves.*

Achievement of Stated Outcomes/Outputs

A comparison of the intended outputs/outcomes specified in the original application and those that actually resulted is provided in Table 1. Reflecting upon these outputs there are a number of critical outcomes concerning the ways in which pre-service mathematics education might progress into the future. These include:

- Evidence around the kind of changes in mathematics education teaching likely to impact the PCK of pre-service primary and secondary teachers;
- Recommendations about effective models of teacher education for the teaching of mathematics;
- Processes likely to initiate change at a unit and course level in universities; and
- Progress towards a national culture of evidence-based practice in relation to mathematics teacher education at both the secondary and primary levels.

There is one output that did not eventuate from CEMENT that was specified in the original application, i.e., the development of a website. Importantly though, this was not due to a lack of effort from the project participants but due to restrictions and impediments within the University of Tasmania. As with all universities there are stringent protocols around what is allowable in relation to web design making it difficult to cut through the red tape. Hence, the website did not unfold. However, to enhance the dissemination of the CEMENT findings, a conference entitled *Building a Culture of Evidence-based Practice in Teacher Preparation for Mathematics Teaching (CEMENT)* was held in June 2012 in Launceston. Immediate feedback about the conference is articulated in the following quote from the newly appointed Project Officer for CEMENT:

> *On my side of things, I can say the conference has received great verbal feedback. We did not do an evaluation of the conference as such, but rather thought the Communiqué commitments would be the best indicators, as these provide us with information about who is intending on keeping the momentum going for the goals of the project.*

Interestingly, a further outcome from the conference was that:

> *Our distribution list now includes 95 people (mostly University academics). This list is of people who have opted in on receiving more information as we get it together (again, the number does include ourselves and project partners) (Project Officer).*

Table 1: Stated versus unintended outputs of CEMENT

Significant Outcome/outputs	**Intended** (in original proposal)	**Unintended** (not in original proposal)
Establishment of the Steering Committee	✓	
Appointment of a project manager with project faciliation operationalised	✓	
Development/trial and online delivery of student survey instrument for both primary and secondary pre-service teacher educators	✓	
Presentation and attendance at Mathematics Education Research Group of Australasia and Australian Association of Mathematics Teachers conference	✓	
Presentation and attendance at the Australian Association for Research in Education and Australian Technology Network Assessment conference		✓
Development/trial and online delivery of an institutional survey for collecting information about the pre-service courses offerred by Australian universities.		✓
Media coverage		✓
Conference at University of Tasmania		✓
Wider collaboration and professional learning that occurred between mathematics educators in participating institutions as involvement in the surveys and interviews initiated rigorous discussion around current practices and potential ways forward in terms of course design and restructure.		✓

Significance of this Project to Mathematics Education

In the original application, CEMENT was described as addressing the following OLT priority areas:

- Academic standards, assessment practices and reporting; and,
- Curriculum renewal by establishing a national set of standards in relation to which universities will gather local data about their own students' performances.

Priority 1

The CEMENT project provides a framework around the pedagogical content knowledge required for pre-service primary and secondary teachers in order to teach mathematics for understanding. Importantly, this framework is based upon evidence collected from a large representative sample of pre-srvice primary and secondary teachers across Australia using a survey that is now available to all mathematics educators. However, not only has it provided standards around what might be expected but it has established a mechanism for assessing pre-service teachers through the online surveys that have been psychometrically validated (Callingham & Beswick, 2011). While the survey was developed as a diagnostic or formative tool, there is no reason why it could not be used in a summative way to assess the degree of PCK held by students pre and post teacher education mathematics units/courses.

Priority 2

Equally critical with the CEMENT project is for the data from the surveys to initiate curriculum renewal as mathematics educators consider the strengths and weaknesses of their current offerings and the ways in which their curricula might be improved. The focus around PCK in this particular project is a major move forward by recognising that it is not just about teachers' mathematical content knowledge or pedgagy that makes a difference to the way in which students build their mathematical understandings. The findings, surveys, and processes developed within CEMENT provide a mechanism for mathematics educators to re-position or re-shape their courses to specifically address the needs of their students and staff.

Documentary evidence analsyed for this report highlighted that this type of change was already underway with participation and awareness of CEMENT helping to ignite professional discussions among many mathematics educators. The result was often an immediate focus on curriculum renewal within individual institutions. Too often, curriculum renewal and change is focused on teachers in primary and secondary schools but without inclusion of our pre-service teacher education students and the individuals who teach them (i.e., mathematics educators), it is not possible to change embedded culture. CEMENT deliberately addresses these components thereby closing this critical gap in the loop. The significance of this is articulated clearly by one of the Steering Committee members.

> *It offers a fairly blunt instrument for investigating pre-service and practising teachers' PCK, but the real significance is that people who engage with the instruments want to modify and improve them and use them with their own students – not just as a measurement tool, but to provide formative feedback to the teacher educator that can be used to fine tune their practice. All the occasions when we've presented the instruments and some findings have generated wonderful discussions amongst teacher educators (and others), about things we seem not to talk about – what we know and how we know it and how we justify our knowledge and practices. For me, the best impact has been in a*

presentation I gave at the 2011 Delta conference on undergraduate mathematics education, to an audience of mathematicians and mathematics teacher educators. I gave them some of the items from our PCK instruments and asked them, in mixed groups, to decide which was the 'best' response from the options provided, and why. This generated valuable discussion about the type of knowledge that teachers needed as opposed to mathematicians, and I hope the outcome was a better understanding amongst mathematicians of the distinctive nature of pedagogical content knowledge. The mathematicians were certainly fascinated by the complexity and nuances in what at first appeared to be mathematically simple tasks.

Sustainability of the Project

In the absence of a specified website for the project, the Steering Committee have worked solidly to ensure dissemination of findings within and across participating institutions. Examples of strategies implemented include:

- Visits to other institutions to work with mathematics education colleagues (e.g., Callingham to Murdoch University, Chick to University of Tasmania, Thornton to Flinders University);
- Representation by members of the Steering Committee at a number of mathematics and general education conferences (e.g., Kissane at the Australian Technology Network Assessment conference);
- Special issue of *Mathematics Teacher Education and Development* (MTED) journal edited by Thornton, Chick and Callingham with a focus on PCK.
- Open invitation for participation in the project across a range of universities thereby broadening the 'hit-rate' and given ownership in the data collected.
- Intended "road shows" with a focus on regional universities.

Reflecting upon the CEMENT project, here are a number of aspects that ensure its likelihood of sustainability into the future.

- Firstly, as mentioned above, the inclusion of not only pre-service students but also mathematics teacher educators increases the chances of long-term change as mathematics units/courses are re-structured to address the weakness identified from the surveys of students.
- Secondly, many of the members on the Steering Committee and project team are well connected in the mathematics education arena being considered *leaders in their field*. Hence, their involvement along with their track records and teacher expertise in the areas or mathematics teacher education and research ensure that the project will impact others.
- Thirdly, during interviews with members of the Steering Committee it was clear that ideas were in place as to ways of not only broadening access to the tools developed as part of the project but also moving the project forward (e.g., ARC applications in planning).
- Finally, in terms of professional standards, the Australian Institute for Teaching and School Leadership (AITSL) outlines the requirements expected for all graduate teachers emerging from teacher education courses. The CEMENT project provides critical insights that will help institutions using these tools to strategically ensure their students are meeting these standards. As expressed by a member of the Steering Committee:

Ongoing attention to our internal practices will take place, as we are engaging in [yet another round of] course modifications, as a consequence of changing AITSL expectations and internal structural curriculum changes at our University. We are change-weary, but the work of CEMENT will certainly inform our course development for some time to come, and hopefully the online surveys will provide *us with some evidence base for some of that thinking. This is a longer-term project.*

In support of the statements made in this section regarding dissemination and sustainability, a Google search of some of the academics who participated in the CEMENT project identified the following papers. Importantly, some of these papers are quite freely available on the internet for student, teacher and stakeholder access. Examples included:

- Building a culture of evidence-based practice in teacher preparation: Instrument development and piloting (2011) (Beswick, K. & Callingham, R.) see http://www.aare.edu.au/11pap/papers_pdf/aarefinal00649.pdf.
- God-like educators in a fallen world (2011) (Chick, H.) see http://www.aare.edu.au/11pap/papers_pdf/aarefinal00667.pdf.
- Diversity or uniformity: Dilemmas and challenges for teacher education (2011) (Goos, M. & Callingham, R.) see http://espace.library.uq.edu.au/view/UQ:275837.
- Professional conversations among mathematics educators (2011) (Callingham, R., Beswick, K., Chick, H., Clark, J., Goos, M., Kissane, B., Serow, P. & Thornton, S.)
- Connecting the beliefs and knowledge of preservice teachers (Beswick, K. & Callingham, R.) see ww.ruhr-uni-bochum.de/imperia/md/content/mathematik/Roesken/paper_beswick_mavi.pdf
- Mathematical Knowledge for Teaching of MERGA Members (Callingham, R., Beswick, K., Clark, J., Kissane, B., Serow, P. & Thornton, S.) see http://ecite.utas.edu.au/78865

There is no attempt here to quantify or qualify the value or research impact of these papers as this is provided in the final report by the project team. However, these papers exemplify the variety of information and foci that the team have embraced within CEMENT.

Conclusions

CEMENT is a highly significant project with the potential to have far-reaching impacts on tertiary education around preservice mathematics teachers education. From initial involvement in the project it was clear that enhancing mathematical PCK was a high priority for the project team. The development of a number of tools to not only monitor PCK in pre-service teachers but also within mathematics educators as a collective demostrates the innovative thinking driving the team. The evidence provided from these instruments provides critical insights about the changes required to enhance the teaching in teacher education courses, which will ultimately improve the teaching of mathematics in our primary and secondary schools.

References

Callingham, R. & Beswick, K. (2011). Measuring pre-service teachers knowledge of mathematics for teaching. Proceedings of the 2011 Australian Association for Research in Education Conference, 27 November - 1 December 2011, Hobart, Tasmania, pp. 1-14.

Appendix C1: Interim Report October 2011

Office for Learning and Teaching

Culture of Evidence-based Mathematics Education for New Teachers (CEMENT)

Of the Final Report: Building the culture of evidence-based practice in teacher preparation for mathematics teaching

Project Reference: PP10-1638

Interim Report

October 2011

Associate Professor Debra Panizzon

Project Outline

The aim of this OLT funded project entitled CEMENT (**C**ulture of **E**vidence-based **M**athematics **E**ducation for **N**ew **T**eachers) is to provide the tools to promote a national culture of evidence-based practice in the preparation of teachers of mathematics.

Lead institution: University of Tasmania (Associate Professors Rosemary Callingham and Kim Beswick).

Partner institutions: Charles Darwin University (Stephen Thornton), Flinders University (Dr Julie Clarke), Murdoch University (Barry Kissane), University of Melbourne (Associate Professor Helen Chick), University of New England (Dr Pep Serow), University of Queensland (Professor Merrilyn Goos).

Purpose and Scope of the Evaluation

The aim of this evaluation is two fold:

- To critically review the processes, outcomes, significance, and likely sustainability of the project based around gauging the degree of readiness of preservice mathematics students on completion of the mathematics education component of their degrees.
- To provide feedback to the Steering Committee that can be used to enhance the project in the short-term but also in relation to future sustainability after project completion.

Overarching questions guiding the evaluation include:

1. What processes were planned and which were actually put in place for the project? Why any variation?
2. What were the observable short-term outcomes/outputs? To what extent were these intended outcomes/outputs achieved? Were there unintended outcomes/outputs?
3. What was the significance of the project in terms of mathematics preservice teacher education? What were the longer-term benefits of the outputs of the project?
4. What measures were in place to promote sustainability and dissemination of the project's focus and outcomes? Within participating institutions? Other teacher education institutions? Other stakeholders? How effective are these measures likely to be?

Critical Points of the Project to Date

This interim report provides a snapshot of where the project appears from documentary evidence as of September 2011 using the four evaluation questions identified above.

Planned processes compared to those put in place (any variation?)

It would appear that the project is running according to the initial proposal with a number of critical processes in place to ensure the cohesion and operationalisation of the project.

- The establishment of a Steering Committee and appointment of a Project Officer. These two components are central to ensuring the degree of success and effectiveness of the project. With an initial meeting face-to-face meeting in July 2010, a follow up meeting was agreed to in March 2011 because it was felt by the committee that this would allow a issues around the data collecting instruments to be explored collectively. Importantly, the evaluator for the project attended this March meeting. Work from these meetings could be then followed up by the project officer ensuring consistency and cohesion.

- Selection of key personnel (i.e., mathematics educators) within participating instritutions have been identified for inclusion in the project. This is a critical step in that it is these individuals who will ultimately initiate the change in curriculum required to address issues around pedagogy and pedagogical content knowledge that emerges from student survey data and is the broad aim of this study.
- Establishment of a mechanism for the development, trialing and revision of the data collecting instruments for the project so that all participating institutions are involved. Success of this project in the long term requires ownership by participants so that they understand the value of the data collected and how it can shape and enhance offerings within Australian universities for mathematics education preservice teachers.
- Ongoing communication with the project evaluator who is provided with all documentation and emails sent to the Steering Committee.

Observable short-term outcomes – intended versus unintended

To date the outcomes of the project include:

- Establishment of Steering Committee
- Project manager in place
- Student survey instrument under development
- Intention to present a relevant paper at MERGA and AAMT

Hence, the only significant output specified in the original proposal that is not actually established is the website although this is underway with delays caused by issues at host university.

Importantly, there are a number of unintended outcomes that have occurred in relation to the evolving nature of the project and recognition of the need to extend the initial plans. For example, although collection of institutional information about the course structures was proposed, the degree of complexity around this was not anticipated. After considerable discussion this resulted in the development of an actual survey instrument that was inclusive and would accurately capture the scope and nature of programs in university preservice teacher education. This survey has the potential to generate significant information for universities.

Similarly, after the conference at MERGA and AAMT, the decision was made to broaden the survey of teacher educators to include both university personnel (as inintended) but also teachers with schools (unintended). This breadth will ensure that the data are useful and meaningful to the school teaching community thereby enhancing the opportunities for dissemination and sustainability of this project in the longer-term.

Significance of the project for mathematics preservice teacher education - longer-term benefits and impacts

Generating change within universities is extremely unflexible in most instances. Within this project there is huge potential to enhance the offerings provided to preservice mathematics education teachers (both primary and secondary) given the results from these surveys. Having collected the type of data that is emerging, univerisity personnel will be able to alter the emphasis of their content, broaden their pedagogies to ensure that their students complete their degrees with enhanced pedagogical content knowledge around the teaching of mathematics. Importantly, while the participants in this project are driving it at this point, once these surveys are made available more broadly there is scope for all universities to benefit.

Having observed and participated in the rigorous discussion that occurred around the teaching of mathematics and the needs of preservice teachers in this regard during the March 2-day meeting, I would encourage my colleagues in the science education area to embark upon a similar pathway. The potential information to be gained here in terms of informing our own practice in unversities and hence changing the next generation of mathematics and/or science teachers is very exciting and cutting edge.

Sustainability and dissemination of the project's focus and outcomes

It is clear from some of the outputs that dissemination of the project's focus is paramount to those involved in the project. Participation at the combined conference for the Mathematics Education Research Group of Australasia (MERGA) and the Australian Association of Mathematics Teachers (AAMT) was a key initiative given the attendance of a high representation of mathematics educators from all over Australasia along with a strong international contingent. Following this up by allowing these participants to be involved by completing the mathematics educator survey solidifies this impact further.

Likely Directions for the Next Phase of the Project

In reflecting upon the initial proposal and the reports to date, there are a number of aspects of the project to be undertaken in the next phases. While there are indications that these are already under development or in the process of being implemented in participating institutions, there is some work to be done in ensuring that data are collected. This includes:

1. Greater student completion of primary surveys within some institutions given that the data presently appears biased towards those univeristies with higher completions.
2. Given the scope of the project, it is critical to increase the number of responses from secondary preservice mathematics students recognising that there will only be a restricted pool to choose from given the numbers enrolled at this level in participating universities.
3. Completion of the survey or mathematics teacher educators along with interviews.
4. Completion of the institutional survey for each participating university.
5. Establishing the website,which will become critical to the dissemination and sustainability of this project into the future.

Summary

This is a highly significant project with the potential to have far-reaching impacts on tertiary education around preservice mathematics teachers education. From initial participation of the meeting with the Steering Committee in March 2011, the documents read to date (minutes of meetings, Progress Report, Stage 1 Report), and the communications between members of the Steering Committee the project appears on track in terms of meeting the outcomes and outputs articulated in the project proposal. It is difficulty to identify impacts of the project beyond those on the actual participants at this stage, which is to be expected given that they are going to be the major change agents in their particular universities in relation to the mathematics curriculum for preservice teachers. The most imporant change necessary at this stage is for members of the Steering Committee to share a common vision around the scope and purpose of what they are attempting to achieve here so that the findings can be used for future planning in participating universities but also further afield. Importantly, the group has already set in place some actions that will result in sustainability into the future.

Appendix C2: Interim Report April 2011

Office for Learning and Teaching

Culture of Evidence-based Mathematics Education for New Teachers (CEMENT)

*Of the Final Report: Building the culture of evidence-based practice in teacher preparation for mathematics teaching*Project Reference: PP10-1638

Interim Report

April 2011

Associate Professor Debra Panizzon

Purpose and scope

The aim of the evaluation is two fold:

- To critically review the processes, outcomes, significance, and likely sustainability of the project based around gauging the degree of readiness of preservice mathematics students on completion of the mathematics education component of their degrees.
- To provide feedback to the Steering Committee that can be used to enhance the project in the short-term but also in relation to future sustainability after project completion.

Overarching questions guiding the evaluation include:

- What processes were planned and what were actually put in place for the project? Why the variation?
- What were the observable short-term outcomes/outputs? To what extent have the intended outcomes/outputs been achieved? Were there unintended outcomes/outputs?
- What is the significance of the project in terms of mathematics preservice teacher education? What are the longer-term benefits of the outputs of the project?
- What measures have been put in place to promote sustainability and dissemination of the project's focus and outcomes? Within participating institutions? Other teacher education institutions? Other stakeholders? How effective are these measures likely to be?

Data methods and analytical strategy

In order to collect the evidence necessary to address these questions a range of data will be collected including:

- Documentation (i.e., progress reports for OLT; other reports, minutes of meetings or briefing papers distributed to the Steering Committee via email list);
- Attendance at key meetings of the Steering committee (i.e., end of March in Brisbane; final dissemination forum);
- Access to second-hand data including summaries findings from student surveys conducted in participating universities; summaries of interview data with teacher educators (i.e., just to gain a 'big picture' perspective);
- Interviews conducted by the evaluator via phone or skype with Rosemary and/or Kim (as project leaders) to monitor project progress along with an overview of what the student data suggests and how this is being utilised by participating universities to improve mathematics education for teacher education students. These will be conducted prior to the interim and final evaluation reports.
- Interview conducted by evaluator via phone or skype with at least 2 other members (one larger, one smaller university) of the Steering Committee to discuss how the survey data will be used to inform mathematics teacher education practices within the institution.

An overview of how these methods will be applied to the evaluation questions along with the specific foci for the analyses are provided in the table below followed by a proposed timeline for the evaluation.

Evaluation questions	Evidence collected by	Focus
1) What processes were planned and what were actually put in place for the project? Why the variation?	• Documentary analysis of progress reports to the OLT; minutes of meetings, briefing papers • Attendance at key meetings and events • Interviews with Rosemary and/or Kim	Compare the before and after descriptions along with the changes notified in the progress reports to OLT along with aspects identified in interviews.
2) What were the observable short-term outcomes/outputs? To what extent have the intended outcomes/outputs been achieved? Were there unintended outcomes/outputs?	• Analysis of the second-hand data including summaries of findings from student surveys; interview data with teacher educators. • Findings from interviews with the Rosemary/Kim and the other participants from the Steering Committee • Findings from interviews with Deans or significant person in selected universities	Extract the key outcomes/outputs identified as the project progresses. Monitor the extent of these by the time of the interim evaluator report then compare with what has been achieved by the completion of the project. Take care to pick up on those unintended outcomes that may be mentioned or alluded to in passing comments.
3) What is the significance of the project in terms of mathematics preservice teacher education? What are the longer-term benefits of the outputs of the project?	• Findings from interviews with the Rosemary/Kim and the other participants from the Steering Committee • Findings from interviews with Deans or significant person in selected universities • Documentary analysis of progress reports to the OLT	Stepping back from the project, thinking carefully about the more sustainable aspects or outputs (e.g., the online survey) that will be useful in the years to come. Placing this in the broader perspective regarding the importance of supporting our future primary and secondary teachers in the areas of mathematics.
4) What measures have been put in place to promote sustainability and dissemination of the project's focus and outcomes? Within participating institutions? Other teacher education institutions? Other stakeholders? How effective are these measures likely to be?	• Findings from interviews with the Rosemary/Kim and the other participants from the Steering Committee • Documentary analysis of progress reports to the OLT	Stepping back from the project, thinking carefully about the more sustainable aspects or outputs (e.g., the online survey) that will be useful in the years to come. Placing this in the broader perspective regarding the importance of supporting our future primary and secondary teachers in the areas of mathematics. Inclusion of stakeholders outside of the immediate participants/conference presentations to the mathematics community. Discussion about why these components are particularly effective (linking teaching and research).

Evaluation timeline

Months	Actions	Face-to-face	Reports
March 2011	Data collection through document analysis, reading reports, reflecting upon survey results from students What findings emerge from these data in relation to the project outcomes/outputs?	Meeting of Steering Committee Brisbane	
mid July–August	Initial interview Rosemary and/or Kim		
			Submit Interim Report
August	Collation of report		
	Ongoing data collection, collation, analysis through document analysis, reading reports, reflecting upon survey results from students. What findings emerge from these data in relation to the project outcomes/outputs?		
mid June 2012	Interview (s) with key person from universities		
	Follow-up interview Rosemary and/or Kim		
July	Collation of final report	Final dissemination forum (location to be decided)	
August			**Submit Final Report**

Deliverables

Interim Report: Late August 2011
Final Report: Date to be determined by project leaders 2012

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Appendix D: CEMENT Conference Program

Building the Culture of Evidence-based Practice in Teacher Preparation for Mathematics Teaching

CEMENT Conference Program*

*This conference is a working conference. Although we've provided this guide of how we *think* the days will be arranged, it is subject to change based on the discussions over the days and mood of the participants.

The conference will close ensuring plenty of time to travel to the airport for flights out of Launceston.

Day 1

10.00 AM	REGISTRATION & COFFEE
10.30	**Opening:** TBA
11:00	**Key Note Speaker:** Professor Marnie Hughes-Warrington, Deputy Vice Chancellor, ANU
12:00 PM	**Group discussions**
1.00	LUNCH
2.00	Rosemary Callingham & Kim Beswick on **The CEMENT PROJECT**
2:45	**Group Discussions**
3:30	AFTERNOON TEA
4.00	**Student Panel:** The past, the present and the future of education
5.00	FINISH DAY 1
6.30	OPTIONAL DINNER

Day 2

9.00 AM	COFFEE
9.30	Clinical Acumen and Pedagogical Content Knowledge (PCK)
10:00	**Roundtable:** "What is important in your area of teaching?"
11:00	MORNING TEA
11:30	Rosemary Callingham & Kim Beswick on **forming the CEMENT Communiqué**
12:00 PM	**Group Discussions**
1:00	LUNCH
1:45	**Feedback** from the conference group discussions
2:00	**Professor Sue Kilpatrick** responding to conference themes
2:45	**Close:** TBA
3:00	FINISH