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## What teachers' want: Identifying mathematics teachers' professional learning needs

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**Abstract:** *This paper reports on three differing approaches to ascertaining the professional learning (PL) needs of teachers of mathematics that were used in three PL projects. In each case the approach used was constrained to some extent by the project brief, practical considerations, and stakeholders' preferences and abilities to contribute to determining the most useful focus of the PL. Nevertheless, there were consistent efforts to heed the advice in the literature about effective PL focussing on teachers' needs in their particular contexts. The results of each approach are described and lessons about effective ways to identify mathematics teachers' PL needs, and reasons for which teachers might be unwilling or unable to articulate their needs, are drawn from an overall analysis of the findings in relation to relevant literature on effective PL and teacher belief change.*

**Keywords:** Professional learning; teacher beliefs; teacher change; Mathematics teacher professional development

Reports of Professional Learning (PL) initiatives tend to focus on the process and outcomes of the PL often describing how the generally accepted characteristics of effective learning were incorporated in the PL design (e.g., Beswick & Jones, 2011; Muir, Beswick & Williamson, 2010; Watson, Beswick & Brown, 2012). There appears to be relatively little attention to ways in which PL providers find out about teachers' perceived needs and particularly the extent to which these efforts were either effective in eliciting teachers' needs, or in driving PL. This paper examines the efforts made to identify teachers' PL needs and the resulting information obtained in three projects. It suggests circumstances that, when in place, may increase the value of seeking teacher input about their needs and raises questions about the purpose and value of seeking such information in circumstances that are likely to render it ineffective or inappropriate. The role of contextual factors including policy and curricula changes in influencing teachers' PL needs or PL programs is seldom mentioned in the

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literature perhaps because such things are beyond the scope of PL providers to address. A further contribution of this paper is the illustration it provides of the impacts of such factors on teachers' PL needs.

### **Teachers' needs as foci of professional learning**

Common to many lists of features of effective PL is the need for it to address teachers' needs (Sowder, 2007). Different lists place differing emphasis on the importance of involving teachers in the identification of those needs. Elmore (2002), for example, described appropriate PL foci as issues identified from research or considered to be best practice whereas Clarke (1994) proposed that the issues addressed should be in large part identified by the participating teachers. The strongest emphasis on basing PL on teachers' self-identified needs was provided by Hawley and Valli (1999) who claimed teachers should not only be involved in the identification of their needs but also involved where possible in designing the ways in which they might be addressed. Even if the importance of involving teachers in identifying their needs is accepted there are difficulties associated with PL providers finding out directly from teachers what they are.

In addition to the fact that much teacher knowledge is tacit (Eraut, 2000) and hence not available to be shared, there are reasons for which teachers may choose not to share information about their PL needs. Firstly, revealing needs makes one vulnerable and in a professional context is accompanied by the risk of appearing other than competent. This is evident in groups set up to provide opportunities for teachers to discuss their work (Wilson & Berne, 1999) but applies also when teachers are asked to write about their needs knowing that PL providers will read their comments. Secondly, Wilson and Berne (1999) speculated that a climate of anti-intellectualism that they believed had influenced American schooling at the time may have affected teachers' responses to PL. In contexts in which policy settings appear politically driven rather than based upon considerations of evidence, teachers may be reluctant to engage intellectually. Indeed, teachers may justifiably be sceptical about how and to what extent the needs they articulate will actually be factored into ensuing PL. A third and related factor could be teachers' perceptions of the status of their profession. The status of the teaching profession is of concern in many countries (e.g., Australian Council for Educational Research, 2013; Bland et al., 2011; European Commission, 2012; Hargreaves et al., 2006). Teachers who feel under-appreciated may be unlikely to believe that proposed PL will in fact respect or respond to their input. Fourthly, Wilson and Berne (1999, p. 186) pointed to the

“privacy of teaching” as contributing negatively to “the development of critical dialogue about practice and ideas”.

Even if teachers articulate clear ideas about what they see as important issues for PL to address, these may well change over time, perhaps even between the planning and the implementation of the PL (Sowder, 2007). The need for ongoing dialogue in an environment of mutual trust appears necessary not just to facilitate participants’ learning (Borko, 2004) but also to refine and adapt the focus of PL in as ongoing process (Wilson & Berne, 1999).

### **Learning as beliefs change**

Considering teacher learning from the perspective of beliefs change can offer some useful insights into the issues raised in the previous section as well as highlighting some additional points relevant to the identification of teachers’ PL needs.

Sowder (2007), in her review of literature on the mathematical education and development of teachers included among the goals for that development, the growth of a “sense of self as a teacher of mathematics” (p. 167). PL is inextricably linked to beliefs about oneself or one’s identity as a competent teacher. Beliefs about oneself are among the most centrally held (Cooney, Shealy & Arvold, 1998) in the sense of being strongly and extensively interlinked with other beliefs in the one’s belief system (Green, 1971). Beliefs connected to those about self as a competent teacher of mathematics are likely to include beliefs about what it means to teach and to learn mathematics, how and under what conditions mathematics teaching and learning occur most effectively, the teachers’ role, and students’ capacities to learn mathematics (Beswick, 2007). Beliefs in relation to any of these things could be objects for change from the perspective of a PL program. The greater the extent of their connection to teachers’ beliefs about themselves the greater the likelihood that change to them will be experienced as personally confronting, emotional, and difficult, and hence resisted. It is unsurprising that stories of profound teacher belief and practice change are often represented in terms of personal transformation as the result of a long and sometimes difficult journey (e.g., Chapman & Heater, 2010).

Wilson and Cooney (2002, p. 134) claimed that “teachers’ beliefs can change when they are provided opportunities to consider and challenge those beliefs”. Given that the provision of such opportunities is an important role of PL, its effectiveness would seem to be dependent upon it addressing relevant beliefs. A necessary pre-requisite would be that PL providers are aware of the relevant beliefs that teachers bring. Logically, teachers have at least three

categories of beliefs about their PL needs. These are: (1) beliefs of which they are aware and are happy to share. These are likely to relate to things without close connection to their identity as a competent mathematics teacher such as needs for more time, or concrete resources – all things that can be addressed without personal challenge; (2) beliefs of which they are aware but are unwilling to share (for reasons including those outlined in the previous section); (3) beliefs of which they are not aware. Getting teachers to reveal beliefs in the second category requires addressing issues of trust (Wilson & Berne, 1999) that may include wider cultural and societal issues such as the status of teachers and teaching. The third category cannot, by definition, be uncovered by asking teachers directly about their needs. It may be possible, however, to bring beliefs in this category to teachers' consciousness by providing appropriate prompts to which they can respond. This may happen at the start of a PL program. Alternatively and/or in addition, revealing these beliefs with a view to addressing them, can be seen as part of the role of PL.

### **THREE PROFESSIONAL LEARNING PROJECTS**

An overview of relevant contextual information is provided before each of the three projects is discussed in turn.

#### **Context of the projects**

The three projects were conducted in the Australian island state of Tasmania. Tasmania with an area that is about half that of England occupies just 1% of Australia's land area (Geoscience Australia, 2009) with mountainous terrain in parts and a geographically dispersed population of approximately 0.5 million (Tasmanian Department of Treasury and Finance, 2012). In addition, Tasmania is Australia's most economically disadvantaged state. More than one third of the population is dependent upon government financial assistance (ABS, 2007), and only 55% of students complete Year 12, compared to a national average of 62% (ABS, 2008).

In Australia, as in many European countries, numeracy is used to refer not only to the use basic, largely computational skills in everyday contexts but also to the application of a much wider range of mathematical skills. It is thus akin to Steen's (2001) notion of quantitative literacy or De Lange's (2003) mathematical literacy. In most Australian states, including Tasmania the first year of secondary school is Year 7.

The period over which three projects upon which this paper is based were conducted (2004-2007) was a time of considerable curriculum upheaval in Tasmania. Early in the period an

innovative values-based curriculum framework was established with an emphasis on pedagogy and cross-curricula learning (Department of Education, Tasmanian [DoET], 2002, 2003). The Essential Learnings (ELs) frameworks 1 and 2 identified 18 Key elements within five ELs (Thinking, Communicating, Social Responsibility, World Futures and Personal Futures). Traditional learning areas such as mathematics were not specifically addressed but “Being Numerate” was a key element in the Communicating Essential against which teachers were required to report from 2005. Despite extensive consultation throughout its development and considerable investment in PL for teachers, the ELs curriculum encountered controversy as it was implemented. This culminated in 2007 with the introduction of a new Tasmanian curriculum (DoET, 2007). Although announced as a refinement of the ELs, the new curriculum framework identified eight curriculum areas that aligned with traditional school subjects and included Mathematics/Numeracy. Further detail of the circumstances surrounding the demise of the ELs is provided by Watson, Beswick and Brown (2012).

### **Being Numerate in the Middle Years (BNMY)**

BNMY was a 6-day PL program aimed at improving numeracy outcomes of middle years (Years 5-8) students that ran over a single year in each of 2004, 2005 and 2006. In the first iteration the 6 days were fitted into the period August to November (the end of the school year) but in subsequent iterations they were able to be spread across the school year in three pairs of consecutive days. In each case between 37 and 52 teachers, made up of 3-5 from each school participated. The first 2 years involved secondary schools and their feeder primary schools, whereas in the third year participants were drawn from K-10 district schools. Most of the secondary teacher participants across the three years reported having taken mathematics courses as part of their university teaching degrees and some had completed bachelor degrees in Science with components of mathematics prior to their teaching qualification. The primary teachers reported having studied mathematics curriculum units as parts of the pre-service teaching qualifications. The program was delivered by members of the state and district numeracy teams and university mathematics education researchers. Details of the program and its outcomes were reported by Watson, Beswick, Caney and Skalicky (2006) and Watson and Beswick (2011).

#### *Identifying the needs of the BNMY teachers*

The content of the first iteration of the program was determined on the basis of the experience of the DoET numeracy support team, research on the development of student and teacher

understanding, and input from a teacher representative from each of the participating schools. Throughout the program, including its second and third iterations, adjustments were made on the basis of presenters' observations, teacher feedback collected at the ends of each session, teacher profiles completed on the first and last days of each iteration.

*Teacher profile.* The teacher profile, adapted from that of Watson (2001), included sections designed to assess an holistic conceptualisation of teacher knowledge that included teacher beliefs and confidence as well as the seven aspects of teacher knowledge identified by Shulman (1987). In the context of mathematics teaching the seven knowledge types were; (a) mathematical content knowledge, (b) general pedagogical knowledge; (c) mathematics curriculum knowledge; (d) mathematical pedagogical content knowledge; (e) knowledge of mathematics learners; (f) knowledge of education contexts; and (g) knowledge of the ends, purposes, and values of education related to mathematics. Teachers were asked about their confidence to develop students' understanding of each of fractions, decimals, percent, ratio and proportion, numeracy across the curriculum, critical numeracy in the media, mental computation (addition and subtraction of whole numbers), mental computation (multiplication and division of whole numbers), and operations with fractions. In addition, teachers were asked about their PL needs in relation to each of; their personal understanding of mathematics, resources, using technology, understanding students as learners, assessment of understanding, and teaching for understanding. Although data from all sections of the profile provided insight into the content and nature of PL that might be beneficial, the sections asking about their confidence in relation to teaching various aspects of middle school mathematics and their PL needs are of most direct relevance.

#### *PL needs of BNMY teachers*

The DoET numeracy support team and school representatives were concerned about the teachers' ability to teach mental computation related to learning tables, and fractions, decimals, and percentages. Secondary teachers were, unsurprisingly more confident on average than their primary colleagues. All teachers were most confident about their ability to teach mental computation involving the addition and subtraction of whole numbers. Aspects in relation to which both primary and secondary teachers tended to be least confident were *ratio and proportion* and *critical numeracy in the media*. Teachers reported relatively little confidence in relation to *connecting numeracy across the curriculum*, and operations with both fractions and decimals.

Teachers' responses to the profile section asking them to nominate their PL needs are shown in Table 1 in relation to each of the six categories that they were prompted to consider. The figures are percentages of the total number of teachers who completed the profile. The 'no response' category includes those who left the space blank or provided a response that was uninterpretable. 'Required without comment' indicates a brief response indicating a need but providing no elaboration (e.g., "yes", "a major need"). The total percentages of teachers who expressed a need for PL with or without comment are shown in the italicised row. For each category from one fifth to almost one half of teachers did not provide a response and many of the teachers who indicated that PL was required in a particular area provided no further elaboration. The areas in which teachers most commonly expressed a need for PL were in relation to *resources*, their *personal understanding of mathematics*, and *assessment of understanding*.

Table 1

Overview of teachers' self-assessed PL needs at the start of the first BNMY program ( $n=48$ )

	Personal understanding of mathematics	Resources	Using technology	Understanding students as learners	Assessment of understanding	Teaching for understanding
No response	22.9	22.9	33.3	43.8	27.1	47.9
Required without comment	35.4	6.3	27.1	16.7	37.5	27.1
Required with comment	37.5	66.7	33.3	31.3	35.4	25.0
<i>Total required</i>	<i>72.9</i>	<i>73.0</i>	<i>60.4</i>	<i>48.0</i>	<i>72.9</i>	<i>52.1</i>
Not required	4.2	4.2	6.3	8.38	0.0	0.0

Of those teachers who indicated a need and provided some further comment, most addressed the area of *personal understanding of mathematics* in relation to their teaching. Nevertheless, comments related to the ELs curriculum rather than to aspects of mathematical content. For example, one wrote, "My understanding of how mathematics and numeracy fits in with the ELs Framework needs to improve". Several teachers identified specific content areas, such as decimals and fractions, in terms of communicating ideas to students.

Overall, *resources* was the category in relation to which teachers made the most comments with new materials and time two issues that many teachers raised. The comments regarding material resources included needing “multiple copies,” and “concrete aids.” Several teachers alluded to a need for resources regarding the sequencing of ideas, Comments about time included being able to plan “individually and collectively” and needing time “to make and discuss use of [resources] with other teachers.” Issues of access and availability arose in the area of *using technology*, which are perhaps not as relevant in terms of professional learning; however, several individual teachers indicated that PL would helpful in relation to the more effective use of ICT in planning and to enhance students’ learning would be useful.

Few teachers made specific comments on *teaching for understanding* but several teachers emphasised the need to link concepts to everyday life. Most of the comments regarding *assessment of understanding* focused on assessing numeracy within the ELs framework. Two teachers mentioned that moving beyond testing and tasks that did not involve “a pen and paper test or computer test” was an area of need for them.

Issues regarding student engagement and catering for students’ diverse needs arose for some teachers in assessing their needs in relation to *understanding students as learners*. One teacher commented, “Would like to gain better understanding about the different ways children may think - different strategies to offer them.”

### **Providing the Mathematical Foundation for an Innovative Australia within Reform-Based Learning Environments (MARBLE)**

MARBLE was a 3-year project (2005-2007) conceived in the context of the newly developed ELs curriculum and operating through the time in which ELs were replaced with a new Tasmania curriculum. It was founded on a view of PL as development of knowledge holistically defined to include Shulman’s knowledge types applied to mathematics, teacher confidence and beliefs (Beswick, Callingham & Watson, 2012). PL was provided by university mathematics education researchers, and relevant personnel from the DoET and Catholic Education Office (CEO). The major aims of the project were:

1. To investigate the effectiveness of school-based, negotiated PL for teachers of mathematics that is consistent with recommendations of research in the field and evaluated in terms of evidence-based student and teacher outcomes.
2. To develop a model and make recommendations for effective teacher professional learning that meets the requirements of both reform and innovation.

The project involved all middle school teachers in nine schools, forming two clusters – one in the south of the state and one in the north. One of the northern schools, one was part of the Catholic school system while the others were government schools. The government schools comprised four district schools (K-10), 3 primary schools, and one secondary school (7-10). The Catholic school catered for students in Years K-10. Because of transfers among schools and some overlap of schools involved, some of the teachers in MARBLE had been participants in BNMY (Watson et al., 2012).

As described by Watson et al. (2012), although the same schools were involved across the 3 years of the project, the numbers of teachers varied from 42 at the start of the first year to 54 at the start of the final year. This represented a total of 86 teachers who were involved in the project for some part of the time. Of these, just 19 participated for the full 3 years. High teacher attrition was largely a consequence of high rates of transfer out of the schools, most of which were considered difficult to staff. Eight of the teachers who participated in the first year and none in subsequent years claimed to have studied enough mathematics to amount to a major in the discipline (Watson et al., 2012). Aspects of the project and its outcomes have been reported in Beswick et al. (2012), Beswick, Watson and Brown (2006), Watson, Beswick and Brown (2006), and Watson, Beswick, Brown and Callingham (2007).

#### *Identifying the needs of the MARBLE teachers*

As in BNMY, a teacher from each participating school met with the researchers, DoET and CEO personnel prior to the start of the project to discuss the PL needs of middle school teachers in their schools and all teachers commencing the program were asked to complete a teacher profile that included sections on their confidence to teach aspects of mathematics. In addition, teachers in the southern cluster provided feedback on an initial PL day that was conducted prior to the start of the project, exit surveys that included questions about PL needs were administered to teachers leaving the project before its conclusion, and teacher input was sought throughout the 3 years in meetings of the school representatives, researchers, and DoET and CEO personnel, as well as informally in the context of PL sessions where all participants were present.

*Teacher profile.* An initial teacher profile, similar to that used in BNMY, was administered at the start of the project and where possible to new teachers at the start of subsequent years. The final profile was administered at the end of the 3 years and to teachers leaving the project at any time whenever this was feasible. Despite efforts to capture all beginning and finishing

teachers, just 25 teachers completed both profiles. The most relevant sections to ascertaining teachers' PL needs asked teachers to rate on 5-point Likert scales their confidence in relation to a range of aspects of mathematics teaching and asked teachers to identify their PL needs in relation to each of seven aspects. The confidence items related to; fractions, decimals, percent, ratio and proportion, Measurement, Space, Pattern and Algebra, Chance and Data, mental computation, connecting mathematics to other key learning areas, critical numeracy in the media, and assessment of 'Being Numerate' against the ELs standards. Teachers were asked to indicate their PL needs in relation to each of; your personal understanding of mathematics, resources and concrete materials, using technology and the media, understanding students as learners, assessment of understanding, teaching for understanding, and linking your mathematics teaching to the other ELs key elements.

#### *PL needs of MARBLE teachers*

The concerns of DoET and CEO personnel and school representatives were broadly the same as for BNMY in that they recommended a focus on mental computation and fractions, decimals and percent. As reported by Beswick et al. (2006) in relation to the strands of the mathematics curriculum, the teachers expressed most confidence about teaching *Measurement* and *Space*, and least confidence in relation to *Pattern and Algebra*. Approximately one third of teachers also indicated a lack of confidence in relation to each of *fractions, decimals, and percent*. Teachers were particularly lacking in confidence in relation to *ratio and proportion*. Fractions, decimals and percent are, of course, connected to proportional reasoning and constitute arguably the most crucial elements of middle school mathematics (Sowder, Armstrong, Lamon, Simon, Sowder, & Thompson, 1998). Approximately one third of the teachers expressed a lack of confidence in their ability to make connections between mathematics and the Key Elements of the ELs and to assess the Being numerate key element against the ELs standards.

Table 2 shows the results of a similar categorisation to that used for the BNMY responses, of teachers expressed PL needs in relation to each of the eight aspects on which they were asked to comment. The figures are percentages of the total number of teachers who completed the profile. From close to one third to approaching two thirds of teachers provided no meaningful response. The areas in which teachers most commonly expressed a need for PL were in relation to *teaching for understanding, using technology and the media, and resources and concrete materials*.

In relation to *personal understanding of mathematics*, few responses identified specific topics. There were single mentions of the curriculum strands Chance and Data, and Space as well as problem solving, decimals, ratio and percent. Many comments related to pedagogy, for example, “Better ways to teach topics. Knowing what we do not need to teach in primary school. How we can get parents, who wish to, to help students” and “Reminders of how children develop mathematical concepts. How to reach those kids who "just don't get it”.

Comments on resources focused on the need for more concrete materials and the need for time to become familiar with their use and to incorporate them into planning. Some teachers expressed a need to for greater awareness of what is available. Technology related needs included a desire for more computers; improved access to computers; more ideas, activities, software and recommended websites; and more time for planning. Several responses reflected a desire to better use technology to support students’ learning. Individual teachers expressed a need for learning about particular software packages and applications such as spread sheets, as well as graphics calculators.

The very high non-response rate in relation to using the media appears to reflect a lack of familiarity with using it as a teaching resource. The few comments provided support this. They included “Haven't really used this as a resource”, and “have not used the media in relation to numeracy”.

Table 2

Overview of teachers' self-assessed PL needs at the start of the MARBLE program ( $n=42$ )

	Personal understanding of mathematics (%+ Resources and concrete materials	Using technology	Using the media	Understanding students as learners	Assessment of understanding	Teaching for understanding	Linking your mathematics teaching to other ELs key elements	
No response	45.2	38.1	35.7	61.9	54.8	50.0	28.6	54.8
Required without comment	14.3	16.7	21.4	16.7	16.7	14.3	23.8	31.0
Required with comment	33.3	35.7	33.3	11.9	16.7	26.9	42.9	4.7
<i>Total required</i>	<i>47.6</i>	<i>52.4</i>	<i>54.7</i>	<i>28.6</i>	<i>33.4</i>	<i>41.0</i>	<i>66.7</i>	<i>35.7</i>
Not required	7.1	9.5	9.5	9.5	11.9	9.5	4.8	9.5

Comments made in relation to *understanding students as learners* were quite generic and included “Have learnt a lot through observation and reading”, “I don't really, with regard to numeracy”, and “Could know more, probably”. One expressed an interest in learning about differences in male and female thinking.

In relation to *assessment of understanding* many teachers related their comments to the ELs frameworks. Many also mentioned approaches to assessment that the DoET was advocating in connections with the ELs curriculum. These included the design and use of rubrics for assessment, designing tasks and ways of assessing without using tests.

Teachers' comments about their needs in relation to teaching for understanding included a desire for PL that was mathematics specific and that included practical examples (in contrast to the extensive PL that had been provided about this aspect in a generic sense as part of the implementation of the ELs), to find out about primary teachers teach. Teachers' responses included, "How do I know they really understand?" and they were concerned to learn strategies that would assist students to "retain knowledge and skills".

Comments on linking mathematics with the ELs were few. Those offered were positive about working collaboratively (as encouraged by the DoET as the ELs were being implemented) or expressed a desire for more sharing.

### **Building Mathematics Teaching and Leadership Capacity (BMTLC)**

The BMTLC project ran in 2007 and offered an intensive week of PL to teachers in three geographically isolated schools. The project was sponsored by the Australian Association of Mathematics Teachers (AAMT) and its aims were:

1. To provide support for teachers of mathematics in a cluster of remote Tasmanian schools.
2. To develop mathematics curriculum leadership in the area.
3. To raise the profile and impact of the Mathematical Association of Tasmania (MAT), an affiliate of the Australian Association of Mathematics Teachers (AAMT), in the area.

The model, described in detail by Beswick and Jones (2011), involved sending a team of five PL providers made up of university academics and DoET personnel to the school cluster for 1-3 days each over the course of the same week to provide a total of 10 person-days of PL. It was designed to respond to the specific needs of teachers in their teaching context and to avoid the difficulties inherent in having to travel to a larger centre for PL. Two of the schools catered for students in Years K-12 and had enrolments of 610 and 380 students while the third, a K-6 school, had an enrolment of 70 students.

A total of 43 teachers of mathematics from K-12 participated in at least one part of the PL program. No more than three teachers had any university mathematics as part of their qualifications. Of these, one, who taught Year 11 and Year 12 mathematics across the two schools that catered for these year levels, had a major in mathematics. The remaining two taught Year 9 and Year 10 mathematics. Enrolments in the senior secondary years were small

with many students opting to relocate to a larger centre to study in schools with the capacity to provide a broader range of courses at this level.

*Identifying the needs of the BMTLC teachers*

The project organiser who was not one of the PL providers visited the schools for 2 days prior to the PL week to administer a survey, conduct informal interviews with the principals and teachers (individually and in groups), and to negotiate the details of arrangements for the PL week. A 15 page summary of the data gathered in this exercise was provided to the PL providers several weeks before they visited the schools. The schools were provided with brief biographies of the PL providers along with ways in which they were happy to work with teachers (e.g., working with individual or small groups of teachers, conducting demonstration lessons, working alongside teachers in their classrooms, running after-school workshops) and a timetable indicating which PL providers would be in the area on which days and in which schools they would be based for particular days (the PL providers' time was divided amongst the schools in proportion to their enrolments). Schools were asked to add to the timetable the names of teachers who would work with each PL provider at each time and the kinds of activities and topics that they wanted.

*The teacher survey.* The survey included an AAMT survey designed to help teachers to reflect on their own work in relation to the Standards for Excellence in Teaching Mathematics (AAMT, 2002; 2006). These sections asked teachers to respond on three 4-point Likert type scales to items that addressed: their professional knowledge of students, of mathematics, and of students' learning; and their professional practice. The three scales for each item related to, (1) the importance of the item in their context, (2) their self-rating of their own knowledge, and (3) the priority of each aspect for improvement/PL. Additional items were similar to those used in teacher profiles in both BNMY and MARBLE. They included items asking teachers to rate their confidence to teach; whole number place value, addition and subtraction of whole numbers, multiplication and division of whole numbers, fractions, decimals, percent, ration and proportion, Measurement, Space, Pattern and basic Algebra (K-8), algebra (beyond Year 8), Chance and Data, mental computation, and connecting mathematics to other key learning areas. Open response items prompted teachers to nominate topics that were difficult to teach, and to indicate their PL needs in relation to; their personal understanding of mathematics, resources and concrete materials for

mathematics teaching, using technology and the media in mathematics teaching, understanding students as learners of mathematics, assessment of students' understanding of mathematics, and teaching mathematics for understanding.

### *PL needs of BMTLC teachers*

Conversations with teachers and principals were consistent with the results of the survey and although far less detailed. The survey results that relate directly to PL needs are summarised below.

Teachers' confidence was greatest in relation to teaching operations with whole numbers, particularly addition and subtraction, measurement, whole number place value and mental computation. Teachers were least confident about *Algebra (beyond Year 8), ratio and proportion, connecting maths to other key learning areas, Chance and Data, percent, Pattern and basic Algebra (K-8), decimals, and fractions*. Time and money were nominated by early childhood teachers as difficult to teach and ICT and problem solving by teachers of middle and upper grades.

Teachers' priorities for PL with respect to their knowledge of students were in relation to their students' feelings and confidence about learning maths. In relation to knowledge of mathematics, priorities for PL related to knowledge of *connections within mathematics and between mathematics and other subjects*, and the mathematics content that they teach. The latter was ranked most important and also most highly in terms of existing knowledge in spite of it being a PL priority. Despite being prioritised for PL, connections between maths and other subject areas was not ranked highly in terms of its importance. In relation to knowledge of students as mathematics learners teachers' considered knowing "a range of effective techniques and strategies for promoting enjoyment of learning and positive attitudes to maths" and "a range of effective strategies and techniques for teaching and learning maths and learning sequences in maths" to be important and also top priorities for PL.

In relation to the learning environments they created, teachers regarded the creation of a safe inclusive environment where engagement with mathematics was valued, students were empowered to be independent learners, individual needs were met, and students were motivated to enjoy and be interested in maths as most important and also as among the highest priorities for PL. Motivating students to improve their maths understandings was rated less important but was among the most highly prioritised items for PL. Of the PL

priorities, teachers rated themselves relatively low in relation to their ability to motivate students both to understand maths and to enjoy and be interested in it.

In relation to their planning for teaching, teachers prioritised using a variety of appropriate teaching strategies, accounting for their students' backgrounds and prior maths learning, using available technologies, providing opportunities for students to explore and apply maths across key learning areas, and building on and enriching students' existing knowledge and appreciation of maths. Of these using technologies was considered less important and teachers, on average ranked themselves lowest in relation to this aspect of their practice.

In terms of their teaching, teachers prioritised providing challenging, engaging lessons that stimulated students' curiosity and supported creativity and risk-taking in finding and explaining solutions. These were among aspects considered most important along with modelling mathematical thinking and reasoning. On average, teachers rated themselves lower for "promote, expect and support creative thinking and mathematical risk-taking in finding and explaining solutions" than for any other aspect.

Teachers indicated that they regarded the most important role of assessment to be providing purposeful feedback to students. They rated themselves highly in terms of feedback to both students and parents and indicated that providing feedback was not a priority for PL. Rather teachers prioritised PL on using records to plan for future learning, maintaining records and using fair, defensible and inclusive assessment strategies.

Table 3 shows teachers responses to the open items asking about their PL needs in six categories analysed in the same way as similar items in BNMY and MARBLE. The figures are percentages of the total number of teachers who completed the survey. The areas in which teachers most commonly expressed a need for PL were in relation to resources, using technology and the media, and personal understanding of mathematics.

Table 3

Overview of teachers' self-assessed PL needs at the start of the BMTLC program ( $n=42$ )

	Personal understanding of mathematics	Resources and concrete materials for mathematics teaching	Using technology and the media in mathematics teaching	Understanding students as learners of mathematics	Assessment of students' understanding of mathematics	Teaching mathematics for understanding
No response	34.2	34.2	34.2	52.6	44.7	47.4
Required without comment	2.6	5.3	21.1	15.8	26.3	26.3
Required with comment	55.3	60.5	39.5	18.4	26.3	23.7
<i>Total required</i>	<i>57.9</i>	<i>65.8</i>	<i>60.6</i>	<i>34.2</i>	<i>52.6</i>	<i>50.0</i>
Not required	7.9	0.0	5.3	7.9	2.6	2.6

Teachers' comments about their needs in terms of *personal understanding of mathematics* concerned mainly generic issues rather than specific mathematical content. Individual teachers mentioned, for example, needs in relation to catering for diversity, learning sequences, teaching, and helping high and low attainers. The six mentions of specific mathematics topics or curriculum strands all came from teachers of Years 3-6. These were decimals, and chance and data (both mentioned by two teachers), and percent, and algebra for primary students which were mentioned once each.

In relation to *resources and concrete materials for mathematics teaching* teachers expressed needs for specific concrete materials such as counters, games, software, calculators and "good" texts. Rich tasks were mentioned by one K-2 teacher and another teacher of Years 9-12. The majority of responses were, however, non-specific and included "What good

resources are out there?”, “resources to engage low ability students”, and “related to each focus area”. One Year 9-12 teacher mentioned resources for teaching a particular Year 11/12 mathematics course.

Needs related to *using technology and media in mathematics teaching* included, “good” TV recordings, maths programs and CD ROMS, calculator activities, software, games and engaging tasks. Several teachers simply said they needed more. Teachers of younger students were more likely to provide comments in relation to technology and media than were teachers of older students.

*Understanding students as learners of mathematics* was the area in relation to which teachers were most likely either not to respond or to indicate that PL was not required. Aspects that were mentioned as PL needs included learning styles, individual needs, assessment strategies, and understanding how kids think.

In terms of *assessing students’ understanding of mathematics* teachers indicated that PL about different, alternate and authentic assessment, open-ended tasks, and assessment that is “quick and informative” would be useful, as would time to work with others teaching the same year level. Similar comments were made in relation to *teaching mathematics for understanding*. Teachers mentioned ways of grouping students, “what to do with reluctant learners”, “good assessment tasks”, “brain research”, and “helping under-achievers”.

### **Summary of perceived PL needs**

There were commonalities in the PL needs the teachers indicated in relation to the slightly varied categories that they were prompted to consider in surveys at the start of each of the projects. Resources were among the three most commonly indicated areas of PL need in all three projects, technology or technology and the media was included in this list for two of the three project (MARBLE and BMTLC), as was personal understanding of mathematics (BNMY and BMTLC). Assessment of understanding was among the top three for BNMY and the related teaching for understanding was amongst this list for MARBLE.

In terms of confidence, teachers across all projects reported little confidence in relation to teaching ratio and proportion. Related topics such as decimals, fractions and percent were also commonly at the lower end of the confidence scale. Making connections either across between mathematics/numeracy and other curriculum areas (BNMY and BMTLC) or other elements of the ELs (MARBLE) was a further area of relatively low confidence. Teachers in both BMTLC and MARBLE expressed relatively low confidence in relation to algebra. For

BMTLC, possibly because it involved teachers of Years K-12 rather than only Years 5-8, additional aspects in relation to which confidence tended to be low were algebra beyond Year 8, chance and data, and making connections among topics within mathematics.

## **DISCUSSION**

The three projects had in common participants among whom tertiary level mathematics study was rare, who were located in schools that were either difficult to staff and/or located in rural or isolated areas. In each case initial information about the PL needs of the teachers was sought from informed people such as school teacher representatives, principals, DoET and/or CEO personnel involved in the provision of numeracy support, and from the relevant research literature. Each project used a version of written questionnaire that included confidence items, and several categories in relation to which teachers were asked to indicate what they perceived to be their PL needs.

The projects differed in terms of the amount and structure of PL that was provided, varying from a one week intensive program (BMTLC), through to 6 spaced days over a single year (BNMY) through to a 3-year project (MARBLE). The prevailing agenda of the DoE in relation to curriculum and pedagogy, and the priorities of funding organisations – variously the DoET, CEO, and AAMT also differed and largely explain differences in the projects' objectives. All aimed to improve teaching of mathematics/numeracy but MARBLE began with a particular ELs focus with attendant attention to teaching for understanding, working in cross-curricula ways and using authentic assessment, whereas BMTLC had additional aims in relation to raising awareness of AAMT and its local affiliate, and building teacher capacity through, among other things providing them with a tool that they could use to assess their own teaching, and the relative importance and priority for them of a range of aspects thereof.

Particular curriculum regimes in place at the time were influential in relation to teachers' perceptions of their PL needs. The three iterations of the BNMY project all occurred when the ELs curriculum was being implemented and included the year, (2005) in which Being Numerate was first assessed and reported upon. The BMTLC project in 2007 happened post-ELs as teachers were coming to grips with the new Tasmanian curriculum. The period 2005-2007 during which MARBLE ran spanned the period from when the ELs were most fully implemented and Being Numerate was assessed, through the political controversy that led to

its axing, and the announcement, creation and implementation of a new curriculum. PL needs expressed in relation to assessment of understanding and teaching for understanding align with the contemporaneous curriculum developments, with 2004 BNMY teachers preparing to assess the Being Numerate element of the ELs for the first time, and the MARBLE teachers feeling perhaps a little more at ease in relation to assessment but aware of their pedagogical needs in terms of teaching for understanding.

PL related to resources and their uses was consistently most requested. Such requests are legitimate (Wilson & Berne, 1999) but are also less potentially threatening to teachers than other aspects such as personal understanding of mathematics because they relate to things that are external to teachers and that are likely to be relatively easily without challenging their views of themselves as competent teachers. This might explain its prevalence amongst teachers' responses. Although personal mathematics understanding was a commonly perceived need by teachers in two of the projects, references to specific topics were scant and often framed in terms of knowledge of how to help students to understand. This was the case even though the questionnaires included lists of topics in relation to which teachers indicated their confidence.

The three projects illustrate the difficulty of obtaining clear, specific and unambiguous information about teachers' PL needs. It could be argued that the kinds of things that teachers expressed could readily have been predicted from the initial conversations with informed people and the research literature, and inferred from the most pressing change agendas impacting or about to impact their work. The few specific topics that were suggested in relation to teachers' personal understanding of mathematics could, for example, have been predicted on the basis of the literature (e.g., Sowder et al., 1998). If this is the case then taking teachers' time to complete questionnaires would appear wasteful if not unethical. In contrast affording teachers an opportunity to express their needs seems appropriate if accompanied by a commitment and the means to address the issues raised.

The BMTLC teacher survey generated considerable additional detail in relation to these teachers' PL needs which was both helpful and unhelpful in relation to PL providers being able to meet these teachers' needs. The 15 page summary that was provided to them was comprehensive and detailed, and required considerable effort for the providers to process. Even with this information, the PL providers found it difficult to know what materials to take with them and how to prepare for their work with the teachers. Several BMLTC PL providers observed that the teachers appeared to be waiting for them to set the agenda and take the lead

in their work together even though they knew that the PL providers were there to help in whatever way the teachers wanted. The providers reported often responding to teachers' on the spot requests and questions rather than using things they had prepared. In spite of this the school principals were all convinced that the teachers' needs had been met (Beswick & Jones, 2011). In this project the questionnaire also served as a means of teachers their awareness of the AAMT standards, and for helping teachers to reflect on their practice, hopefully with a view to working on key aspects of their choosing over the long term rather than simply nominating things in relation to which they wanted specific PL.

These observations highlight three points likely to have been at play in this case and in the other two projects. Firstly, when the teachers in each of the projects filled out the survey many of their PL needs were in the categories of beliefs of which they were aware but unwilling to share, and beliefs of which they were not aware. Articulating needs essentially "in a vacuum" does not assist teachers to become aware of PL needs that don't spring immediately to mind - hence the brevity and frequent non-responses to the open items about PL needs. Providing prompts such as lists of topics in relation to which teachers rated their confidence, or in the case of the BMTLC project, lists of aspects of their knowledge and practice enabled them to nominate as PL needs things that would not have occurred to them when presented with a broad category and blank space. The act of asking teachers to consider such things, thus, influences the teacher's knowledge/beliefs system and may in fact be part of the PL: the awareness raising aspect of the AAMT survey items in the BMTLC project fall into this category. The second point relates to teachers' need to protect beliefs about themselves, including as competent teachers. This has already been alluded to in relation to the frequency of expressions of PL needs related to resources. When teachers wait for PL providers to take the lead, the assumed roles of expert PL provider and learner are likely to be at play. Although less obvious this same dynamic operates when teachers express their PL needs in written form. Providing generic, brief and ambiguous responses guards against revealing ignorance and the concomitant threat to their identities as competent. As suggested by Beswick and Jones (2011) and Wilson and Berne (1999), relationships in which mutual respect and trust have time and opportunity to develop are key to effective PL. Thirdly, the fact that teachers in the BMTLC project often asked question at the time of the PL that did not necessarily match what they had requested illustrates Wilson and Berne's (2009) point that PL agendas need to be refined in an ongoing process of negotiation.

## CONCLUSION

The three projects discussed have illustrated that calls to involve teachers in determining the focus of PL are not asking for something that is straightforward. Calls for relationships between teachers and PL providers and teachers that are characterised by trust are not new but are nevertheless important and especially so when PL is conducted in broader societal and policy environment in which teachers may not feel valued or respected (e.g., Australian Council for Educational Research, 2013; Bland et al., 2011; European Commission, 2012; Hargreaves et al., 2006) or when encouragement for them to engage intellectually with issues of teaching and learning occurs against a backdrop of apparently politically driven change as was the case in the MARBLE project (Watson et al, 2012).

The evidence from these projects is that the kinds of PL needs that teachers tend to nominate are predictable in other ways. Nevertheless, the act of asking teachers about their needs, including facilitating their ability to bring things to mind by providing lists, is, if acted upon, a first step to building trust that may allow teachers eventually to be more open about their needs.

PL providers need to be mindful that change is difficult and emotive and that teachers are fundamentally driven by the need to develop and maintain their professional identity as a competent teacher (Sowder, 2007). When we ask to teachers to identify their PL needs we are opening the possibility of challenging them to change their thinking about mathematics and the teaching and learning of the subject. In so doing we are asking them to make changes that may have far-reaching consequences for their identities as teachers and more widely (Chapman & Heater, 2010).

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